Document de travail du LEM / Discussion paper LEM
2022-06

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Migrant Smuggling to Europe: a Matching Model*

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March 21, 2022

Abstract

This paper develops a matching model à la Pissarides (2000) to analyze the migrant smuggling market, building on the empirical evidence related to the smuggling of migrants from the Horn of Africa and the Middle East to the European region in the last decade. The model allows us to determine the equilibrium numbers of smugglers and of incoming irregular migrants as well as the total migrant welfare. Most of the coercion-based measures targeting the smugglers achieve the reduction in the number of irregular migrants and smugglers at the expense of migrants' overall welfare. Slightly increasing legal migration opportunities has the interesting feature of drastically reducing irregular flows, without deteriorating migrants' welfare nor increasing the total number of migrants. The model reveals that an extremely restrictive asylum policy has similar effects in terms of the flows of irregular migrants as a quite loose one, with the largest flows of irregular migrants reached for a "middle-range" policy. Finally, the stay-home incentive of generous humanitarian policies might be partially offset by higher profits and a higher smuggling activity.

Key words - Migrant smuggling, Irregular migration, Matching model, Migrant welfare, Europe.
JEL classification - F22, 015, J46

*We thank participants at the LEM economic seminar in 2019, at the GLO Virtual Seminar in 2022, at the CES IELM seminar in 2022 and at the Borders workshop in 2022 for their suggestions and remarks that helped us to improve the quality of the paper. Authors declare no conflict of interest related to this work.

1 Introduction

As a relatively new phenomenon, in the last decade, European Union (EU) member states have recorded a dramatic surge in the number of irregular migrants arriving from the Middle East and the Horn of Africa. In the last few years, the annual flows varied between 100,000 and 150,000 arrivals (Frontex, 2021), with an all time high of 1,046,000 irregular arrivals in 2015, during the height of the Syrian crisis.[1] In perfect synchronisation with the rise of irregular migration flows, another phenomenon developed. According to Europol, the EU Agency for Law Enforcement, 90% of those who cross the EU borders in an irregular way do it with the support of smugglers. At the peak of the crisis, in 2015, the turnover of the European smuggling market was estimated between 3 and 6 billion euros; in 2019, smuggling turnover on the Mediterranean routes only was estimated at about 190 million euros (Lyuten and Smialowski, 2021). This paper seeks to provide an analysis of the smuggling market, and to study the consequences of various policies implemented by the EU to discourage smuggling and reduce the number of irregular migrants coming every year.

As explained by the United Nations Office on Drugs and Crime (UNODC), "criminals are increasingly providing smuggling services to irregular migrants to evade national border controls, migration regulations and visa requirements". The UN Protocol Against the Smuggling of Migrants (2000) defines migrant smuggling as "the procurement, in order to obtain, directly or indirectly, a financial or other material benefit, of the illegal entry of a person into a State Party of which the person is not a national or a permanent resident".[2] Smuggling is the profit-making business of illegally carrying migrants across borders; contrary to trafficking, it does not require an element of exploitation, coercion, or violation of human rights (IOM, 2019). Smugglers provide migrants with the logistics for their long and risky journey, including planning (based on their knowledge of the routes and risks), minimal shelter and food, means of transports, and fake documents; they assure their protection against robbery and other crimes, sometimes bribe officials to close their eyes when they cross the controls (UNODC, 2018; Frontex, 2021; MacKellar, 2020).

Despite the documented importance of the smugglers as facilitators of irregular migration in many policy, legal and sociological studies, theoretical investigations of this activity are relatively scarce (MacKellar, 2020). To our knowledge, Salt and Stein (1997) were the first to describe in a systematic way the successive stages of smuggling and the complex nature of the smuggling activities. The UNODC (2018) uses a traditional supply and demand setting to analyze the market for migrants smuggling. On the supply side, the UN report indicates that "smugglers advertise their business where migrants can be easily reached, such as in neighborhoods home to diaspora communities, in refugee camps or in various social networks online". They explain that migrants demand for smuggling services is "determined by socio-economic conditions, family

[1] See the European Council webpage on the EU migration policy.

[2] Art. 3(a), UN Protocol Against the Smuggling of Migrants by Land, Sea and Air, supplementing the United Nations Convention against Transnational Organized Crime, 2000.

reunification as well as persecution, instability or lack of safety in origin countries". Similar to any market, the smuggling market involves a price paid by migrants to smugglers for their service, the smuggling fee. Petros (2005) reports that smuggling fees depend on the distance travelled, the mode of transport, the number and characteristics of people being moved, and of circumstantial conditions.

Gathmann (2008) introduces a cost/benefit analysis to explain smugglers' choice of the crossing border point, and shows that tighter border control leads to geographic substitution and raises migration costs. Djajić and Michael (2014) investigate how tougher transit cost over a neighboring country can reduce migration.

Several papers have analyzed the financial relationship between migrants and the criminal smuggling organization as a provider of transport services as well as financial resources. Building on the assumptions that many candidates to migration do not have the funds to pay for the smuggling fee, they study the debt contract between the migrant and the criminal organization, which in many cases involves migrant exploitation once he/she reaches the destination, and, in some cases, leads the migrant to default on his/her "obligations" (Friebel and Guriev, 2006; Tamura, 2010, 2013; Djajić and Vinogradova, 2013, 2014). In this context, Friebel and Guriev (2006) show that stricter border controls decrease migration but may increase debt-financed migration. Tamura (2010) suggests that both tighter border controls and inland controls decrease migration flows, but that the latter policy tool may increase the total number of smugglers (increasing the share of non-exploitative ones). However, Tamura (2013) shows that both policy tools may lose their effectiveness when assuming asymmetric information. Djajić and Vinogradova (2013, 2014) find that tougher border controls as well as internal enforcement measures decrease debt-bonded migration (but not necessarily overall irregular migration).

Other scholars focus on the choice between regular and irregular migration, and the interactions between the immigration policies targeting both types of migrants. Djajić and Vinogradova (2019) use a dynamic, intertemporal cost/benefit analysis to determine the migration strategy of a low-skilled worker who can choose between legal temporary migration and long-term irregular migration, and show that there is a trade-off between the various policy instruments.

Auriol and Mesnard (2016) have developed the first industrial organization model of the market for smuggling services. They consider that the smuggling services are provided by a closed oligopoly including a relatively small number of large criminal organizations, similar to the drug cartels. The number of smuggler organizations is given; they engage in monopolistic competition *à la* Cournot, choosing smuggling fees to maximize the profit (rent). The optimal smuggling fee depends on the elasticity of demand and the number of smuggling organizations. Migrants with heterogeneous productivity choose between buying a visa and migrating legally, or paying the smuggling fee and migrating irregularly. The authors find that a combination of tight border controls with the sale of a large number of visas would be an optimal policy, as it would at the same time limit the number of irregular migrants and prevent excessive concentration of the smuggling market (at the cost of drastically increasing the number of legal migrants).

Smuggling activity in the context of forced migration is at the heart of the paper by Brausmann and Djajić (2022). They develop a dynamic macroeconomic model to analyse how the border-control policy of destination countries with a migration target should best respond to the pressure from migration flows. The model builds on two differential equations, one for the change in the stock of migrants, and another one for the change in the amount of resources used to control migration. One key result is that the higher the speed of adjustment of the border-control policy, the lower the spending and the amount of time required to get the system to its new steady state.

While these papers provide very interesting insights, they do not take into account two important features of the smuggling market: trade frictions in matching smugglers with candidates to migration and the importance of multiple attempts to cross the border. Trade frictions are a built-in characteristic of these illegal and opaque markets. Transactions between candidates to migration and smugglers take place in a context of illegality, asymmetric information and low trust (Campana and Gelsthorpe, 2020). The smuggling and migration processes also have an essential flow dimension, with many migrants been pushed-back and increasing the stock of candidates to migration. To account for both trade frictions and the essential flow dimension of the migrant smuggling market, this paper introduces a dynamic model, inspired by the matching labor market model developed by Pissarides (2000),[3] extended to account for the specific features of the smuggling market.

In the model, candidates to migration search for smugglers to facilitate their transit to the destination country (EU), and smugglers search for candidates to migration to hire their services. The illegal nature of smuggling activities implies that both parties willing to trade are facing substantial frictions and will have to wait before departure, even after a match has occured. The probability of a successful match is positively related to the number of smugglers and migrants, via a standard matching function. By comparison with the matching model of the labor market (Pissarides, 2000), a smuggler searching for a migrant is in the same position as a firm searching for a worker and posting a vacancy, while a smuggler matched with a migrant is quite similar to a filled job. By contrast with the traditional labor market model where firms enter the market and pay a wage to workers, in our model smugglers (equivalent of the firms) enter the market but the migrants pay them a wage (the smuggling fee).

Two key assumptions of our model are inspired by the context of irregular migration toward the EU. The context will be presented with additional details in the next section.

The first assumption is related to the industrial organization of the smuggling market. In general, the report by UNODC (2018) indicates that small and family businesses are important players in the human smuggling market, next to the criminal cartels with a strong hierarchical organization. In the case of the smuggling of migrants to Europe, there is recent evidence that most of the smuggling activity is carried out by small businesses, run by largely independent and autonomous higher-level smugglers that compete between them to provide services to a limited

[3] See also Cahuc et al. (2014) for a clear exposition of this model and its extensions.

number of candidates to migration (Abdel Aziz et al., 2015; Campana, 2018). Therefore, we adopt in this paper a small-firm perspective, and allow for smuggler free-entry in this market.

The second assumption relates to the characteristics of the relationship between migrants and smugglers. Several scholars have emphasized the complex nature of the migrants/smugglers relationship (Achilli and Sanchez, 2017; Zhang et al., 2018; Campana and Gelsthorpe, 2020). They argue that smugglers, if they do care about their profits, are not necessarily the selfish reckless persons treating migrants as an expandable commodity only, as described in many economics and policy papers (see European Commission, 2015a; Frontex, 2021). These authors reveal some form of cooperation between smugglers and migrants, as a "rudimentary form of human security from below" (Achilli and Sanchez, 2017). To allow for a reasonable mix of self-interest and cooperation, in our model smugglers and migrants are assumed to negotiate the amount of the smuggling fee, in line with observations from the field (Achilli and Sanchez, 2017; UNODC, 2018; Frontex, 2019), which also note that many migrants finance their journey by selling assets (houses) or through loans from relatives.

The analysis in this paper focuses mainly on forced migration, i.e. on candidates to migration who have no other choice but to flee their country of origin to protect their life and that of their families against the background of wars and natural catastrophes (Ruiz and Vargas-Silva, 2013; Becker and Ferrara, 2019); once they reach the destination area, they apply for asylum. In an extension of the model, we also study the case of voluntary migration, when candidates to migration decide to migrate for economic reasons, following the same routes as forced migrants and applying as well for asylum once in the destination area.[4] The model is solved to determine the equilibrium tension in the market (i.e., the smugglers per migrant ratio), the smuggling fee, the numbers of incoming migrants and smugglers. Changes in the parameters of the model can be related to the various policies implemented by destination, transit or origin countries.

For EU member states, the key policy goal is to control and curb irregular migration through a multitude of policy measures. In turn, these policy measures will have an impact on migrants' welfare, which can be assessed with our framework. Our analysis will distinguish between: (1) "internal" measures that impact migrants' expected payoff from migration conditional on having reached the EU; (2) actions aiming at making smuggling a high-risk low-profit activity; these policy measures involve operational cooperation with governments of both origin and transit countries; (3) humanitarian measures, providing incentives for candidates to migration to abandon their migration project, by improving their living standards at home.

All these policies have direct and indirect (equilibrium) effects with consequences on both sides of the market. We study their impact on the stocks and flows of migrants, their welfare and the number of smugglers.

In brief, the results reveal a tension between the goal of reducing the number of irregular migrants and migrants' welfare. Most of the coercion-based measures achieve a reduction in the number of irregular migrants and smugglers at the expense of migrants' overall welfare. On

[4] In some situations, migrants can respond to a combination of life threats and cost/benefit analysis.

the other hand, slightly increasing legal migration opportunities has the interesting feature of drastically reducing irregular flows, without deteriorating migrants' welfare nor increasing total migration flows. The model reveals that an extremely restrictive asylum policy has similar effects in terms of the flows of irregular migrants as a quite loose one, with the largest flows of irregular migrants reached for a "middle-range" policy. Finally, the model reveals that the "stay home" effect of humanitarian policy might be partially offset by a higher matching value for pushed-back migrants, and a more active smuggling market; the impacts of such policies may differ for forced and voluntary migrants.

To the best of our knowledge, our paper is the first to use a search and matching framework to analyze migrant smuggling. In this respect, our model can be related to a downstream body of literature on the consequences of irregular migration on rich countries' labor markets in a matching approach (Liu, 2010; Chassamboulli and Palivos, 2014; Chassamboulli and Peri, 2015, 2020; Chassamboulli and Liu, 2020; Moreno-Galbis and Tritah, 2016).

The remainder of the paper is organized as follows. Section 2 presents the main stylized facts which lay the foundations for our model. The main assumptions of the model are introduced in section 3. Section 4 determines the equilibrium of the model and analyzes the effect of various policies on key equilibrium variables. Section 5 discusses the specific case of economic migrants. Section 6 analyses the policy implications of the model, backed by several numerical simulations. Section 7 presents our conclusions.

2 The market of smuggling migrants to Europe

It goes beyond the scope of this paper to provide a genuine ethnographic analysis of the 2010s migration-to-EU episode. A significant body of high quality reports by international organizations and research papers are available (see for instance Abdel Aziz et al., 2015; Achilli and Sanchez, 2017; UNODC, 2018; Campana, 2018; Frontex, 2019; Campana and Gelsthorpe, 2020; McAuliffe and Khadria, 2020; Lyuten and Smialowski, 2021). The elements presented in this section only aim to outline the essential features of the smuggling activity that lay the foundations for our model.

No irregular migration without smugglers... As mentioned in the introduction, since 2014, Europe is facing a stable flow of arrivals of irregular migrants and asylum seekers, which reached a one million peak in 2015, and then fluctuates around 100,000-150,000 migrants per year (Lyuten and Smialowski, 2021; Frontex, 2019, 2021). According to UNODC (2018), there were in 2018 three major migration routes into Europe, all involving crossing of the Mediterranean sea. The Central Mediterranean route departs from North Africa, most commonly Libya, and arrives in Italy, usually in Sicily. The Eastern Mediterranean route connects the Turkish coast to various Greek islands, and the Western Mediterranean route departs from Morocco and arrives in Spain, either by sea or overland. Frontex (2021) considers five main migration routes, adding to the three former routes a Western African route, and a land only Western Balkan one.[5]

Virtually all migrants travelling along this route depend on smugglers for the sea crossing. Smuggling migrants to the EU has become of large criminal activity which generates a substantial turnover. An influential Europol report (Europol, 2016), drafted immediately after the 2015 peak in irregular migration to the EU, documents that more than 90% of the incoming migrants were facilitated by criminal networks, whose turnover in 2015 could have totaled between 3 and 6 billion euros. Frontex officers interviewed newly arrived migrants in the Mediterranean area and found that 84% of the migrants interviewed used smugglers services, while only 7% of them arrived in Europe without the help of smugglers (Frontex, 2019). In 2020, Frontex member states reported 8,942 detected smugglers to the organization.

... Organized mostly as small businesses Ethnographic research, based on interviews with migrants, allows to have a good picture of the industrial organisation of this smuggling market. Campana (2018) performed an in-depth empirical analysis of the structure and activities of a smuggling ring operating between the Horn of Africa and Northern Europe via Libya. He revealed that activities are carried out by localized and rudimentary hierarchies with largely independent and autonomous higher-level smugglers. There are also indications of competition among them: Campana (2018) notes that "the presence of multiple independent smugglers in competition among themselves makes it likely that, following the removal of an individual smuggler, the remaining smugglers will try to seize this opportunity to acquire his 'market' share". Similarly, studying smuggling in the Mediterranean area, Abdel Aziz et al. (2015) claim that "small and ephemeral groups participate in the business as well as large and highly professionalized networks. The players in the smuggling market can be organized in a large variety of ways, from structured criminal groups to individual occasional smugglers"; they add that "in general, however, the backbone of the smuggling industry does not seem to be based on highly structured and hierarchical organizations". The same studies suggest that barriers to entry into this business are small; as documented by Achilli and Sanchez (2017), many smugglers are unsuccessful candidates to migration who use their experience to settle as smugglers.

...And charging a smuggling fee There is significant evidence that smugglers and migrants negotiate the price of the smuggling service depending on the characteristics of the journey, including routes and vehicles, security, and duration (European Commission, 2015b; UNODC, 2018). Smuggling fees may also vary with the gender, age and citizenship of the migrants and with the destination countries.

UNODC (2018) mentions that migrants from sub-Saharan Africa would pay around 1,000 US dollars to be smuggled below deck on a boat from Libya to Europe, whereas a Syrian would

[5]Migration routes can change rapidly (as noted by Friebel et al., 2018).

pay 2,500 US dollars or more for a safer seat. Frontex (2019) documents that the migrants who reached Italy from Turkey spent on average 5000 euros per person for smuggling services.

In general, migrants to Europe pay the fee in advance (UNODC, 2018). Abdel Aziz et al. (2015), who studied the migration route in the Mediterranean area, report that for long journeys, the smuggling fee is paid in advance, step by step, through the Hawala or Western Union methods of payment. For other routes, especially for migrants coming from West Africa, one-shot and one-border smuggling services are usually purchased at the border with Libya.

On the other hand, Campana and Gelsthorpe (2020) point out that the payment arrangements can be relatively sophisticated, to avoid opportunistic behavior on both sides of the trade. Sometimes the deal involves a split payment, which increases the risk for the smuggler not to be paid. To address this problem, sometimes a third party is involved (escrow service), to make the payment when the migrant confirms his/her arrival at destination. Sometimes, payment is one way to attract migrants; some smugglers will guarantee several attempts at the same predetermined fee, until the migrant reaches destination.

The EU aims to contain irregular migration The EU is actively seeking to address the issue of irregular migration, by (i) promoting a comprehensive European strategy and (ii) enhancing cooperation with governments in the countries of origin and with governments in transit countries such as Turkey, Jordan or Libya, and by speeding up the management of asylum applicants within the EU borders.

In 2015, the EU carried out a comprehensive review of its migratory policy, including the common resources devoted to improve the situation of the migrants on the one hand, and to fight illegal border crossing on the other hand.[6] Within this ample set of reforms, on May 2015, the European Commission adopted an EU Action Plan against Migrant Smuggling designed to transform smuggling from a "high profit, low risk" activity into a "high risk, low profit" business, while ensuring the full respect and protection of migrants' human rights.[7]

In 2020, the EU issued the Pact on Asylum and Migration with the aim of strengthening coordination and cooperation with third countries by creating a common EU system for returns, which includes a stronger role of the European Border and Coast Guard Agency (also known as Frontex), a newly appointed EU Return Coordinator, and a voluntary return and reintegration strategy (OCDE, 2021).

An important partnership between the EU and a transit country is the European Union-Turkey Partnership. In 2021, Turkey hosts over 4 million refugees, including 3.6 million registered Syrian refugees (European Commission, 2021). The overwhelming majority — 96 percent— of Turkey's Syrian refugee population lives outside of camps in urban locations. Of the 3.6 million Syrians under temporary protection in Turkey, more than 500,000 are known to live in Istanbul;

[6]See the European Commission website: Towards a Comprehensive European Migration Policy: 20 years of EU Action.

[7]The EU is currently adopting a new Action Plan Against Migrant Smuggling for the period 2021-2025: see the European Commission webpage.

thousands more are estimated to live there despite being registered in different provinces or not registered at all. In 2014, to address the Syrian war crisis, Turkey introduced a Temporary Protection system for Syrians. The system grants Syrians access to public services, such as health and education, but does not grant them the full rights accorded to refugees, such as freedom of movement and access to the labor market. The EU is committed to assist Turkey in dealing with the challenge of hosting a substantial number of Syrian refugees. The implementation of the EU-Turkey Statement in March 2016 was a game changer, leading to a substantial decrease of the migratory flows to Greece, with Turkey agreeing to foster its border controls. The EU Facility for Refugees in Turkey, managing a total of €6 billion in two tranches, ensured that the needs of refugees and host communities in Turkey are addressed in a comprehensive and coordinated manner. The Facility focuses on humanitarian assistance, education, migration management, health, municipal infrastructure, and socio-economic support.

Another example of cooperation between the EU and a transit country is the EU Emergency Trust Fund for Africa created in November 2015. It has been the EU's main tool for actions to support migration related issues in Africa, and especially in Libya. The Trust Fund has mobilised €4.9 billion in projects in North of Africa, Sahel and Lake Chad region and the Horn of Africa; 31% of these funds are allocated to improved migration management. For instance, it includes €455 million for projects in Libya, to improve the living conditions of migrants in Libya, stabilize populations, and improve the efficiency of the Libyan border police by providing training and equipment.

An important role in the EU strategy of protecting the EU borders is held by the European Border and Coast Guard Agency (Frontex). The agency, set up in 2004, will benefit of 10000 border and cost guards by 2027, working under a centralised EU commandment. One main goal of the agency is to fight migrant smuggling, by providing appropriate training to national border guards, or launching operational responses. Recently, some humanitarian organisation criticized Frontex as being too harsh on migrants, and sometimes using borderline push-back methods.[8]

Besides governments and the EU, in the last few years, in particular after 2012, the massive migration flows across the Mediterranean sea toward EU countries, in extremely difficult conditions for the migrants, led to a surge in private humanitarian initiatives. The EU and the governments can and do regulate the action of these NGOs, but up to some point. In democratic countries such as the EU member countries, these NGOs have significant autonomy. For instance, many NGOs financed search and rescue vessels to patrol next to the Libyan borders, and provide life support to migrants under distress, then ship them to safe harbors, most often in Italy. According to the report of the EU Agency on Fundamental Rights (EUFRA, 2019), while in 2016 there were approximately 22 ships engaged in such activities, because of the legal actions by EU governments against these NGOs and the general decline in migratory flows, in 2019 the number of actually operating ships declined to no more than three.

[8]See: Frontex saga offers chance to shift EU migration politics, Financial Times, 21 February 2021.

3 The model

In the origin country, a group of candidates to migration searches for smugglers and a group of smugglers searches for candidates to migration.

Smugglers and candidates to migration respectively seek to maximize their intertemporal expected profit and utility. Their decision problem is cast in continuous time. We focus on the steady state equilibrium.

In the destination country, authorities aim at curbing irregular migration and deterring the smuggling business.

As any model, we use a simplified framework to describe the extremely complex situation in the field, as sketched in section 2. Depending on the origin country and the migration route, a migrant might team up with one or more smugglers at different moments during the journey. To keep the analysis relatively simple, we assume that only one smuggler is in charge of taking the migrant from the origin to the destination area.

3.1 The matching function

A fundamental process in the smuggling market is the encounter between candidates to migration who search for smugglers, and smugglers who search for candidates to migration, what is currently referred to as the matching process. This process takes time as it involves a substantial activity of gathering information and building trust on both sides of the market (Campana and Gelsthorpe, 2020), which are referred to as trading frictions in the traditional search and matching literature.

Smugglers use various channels to advertise their business. Typical advertising places are railway stations, cafes or bazaars, and also Internet-based social media (UNODC, 2018; European Commission et al., 2018; Frontex, 2019). World-of-mouth communication is also an important recruiting channel. These searching and matching activities are costly.

A standard matching function, as introduced by Pissarides (2000), allows us to bring into the picture these significant trading frictions. Let M_s be the number of candidates to migration (or potential migrants) searching for a smuggler, and S_s the number of smugglers searching for a migrant. The matching function connects the number of successful matches, $\mathcal{H}$, to the number of searching candidates to migration and smugglers as follows:

$$\mathcal{H} \equiv pH(M_s, S_s), \tag{1}$$

where $p > 0$ is a scale parameter determining the efficiency of the matching process, with $p \to +\infty$ corresponding to the limit case of a frictionless market where matching is instantaneous.

The function H is twice continuously differentiable; it is increasing and concave in both of its arguments, linearly homogeneous and satisfies the Inada conditions and the boundary conditions ($H(0, S_s) = H(M_s, 0) = 0$ for $M_s, S_s \geqslant 0$).

On average, a smuggler meets a candidate to migration at rate $\mathcal{H}/S_s$ while a candidate to migration meets a smuggler at rate $\mathcal{H}/M_s$. We define θ as the smuggler per candidate to migration ratio (the so-called *market tightness*):

$$\theta = \frac{S_s}{M_s}. \tag{2}$$

Linear homogeneity of the matching function allows us to define the two contact rates as a function of this ratio:

$$\frac{pH\left(M_s, S_s\right)}{S_s} = h\left(\theta\right), \text{ with } h'\left(\theta\right) < 0, \tag{3}$$

and

$$\frac{pH\left(M_s, S_s\right)}{M_s} = g\left(\theta\right), \text{with } g'\left(\theta\right) > 0. \tag{4}$$

As an example that will be used later on for numerical simulations, one might think of the matching function as being of the Cobb-Douglas form:

$$\mathcal{H} = pM_s^{\alpha}S_s^{1-\alpha}, \tag{5}$$

where $\alpha \in (0,1)$ is the elasticity of the number of successful matches with respect to M_s. In this case,

$$h\left(\theta\right) = p\theta^{-\alpha} \text{ and } g\left(\theta\right) = p\theta^{1-\alpha}. \tag{6}$$

Obviously θ, $h\left(\theta\right)$ and $g\left(\theta\right)$ are related, since the number of candidates to migration meeting a smuggler must be equal to the number of smugglers meeting a candidate to migration:

$$M_s g\left(\theta\right) = S_s h\left(\theta\right) \Leftrightarrow g\left(\theta\right) = \theta h\left(\theta\right). \tag{7}$$

3.2 Key stages of smuggler-assisted migration

Irregular migration is a long and complex process involving different stages, as firstly defined by Salt and Stein (1997) and also by the more recent literature on migration to Europe (UNODC, 2018; Campana and Gelsthorpe, 2020; Brausmann and Djajić, 2022). Figure 1 summarizes these stages, focusing on the status of the migrants. Figure A.1 in the Appendix presents the same stages from a smuggler perspective.

The first block represents the stock of candidates to migration (M_s).

Arrivals into this pool of people includes two flows. First, there is a flow of N new candidates per period. In a first part, our analysis will focus on the situation of refugees, and take N as a constant, in line with a substantial literature on *forced migration* (Ruiz and Vargas-Silva, 2013; Becker and Ferrara, 2019; Brell et al., 2020). Forced migrants have little choice but to leave their homes because their life and the life of their family is under threat. In the 2010s, many migrants coming to Europe had left conflict area in Syria, Afghanistan, Somalia, etc. (Piguet, 2020; Brausmann and Djajić, 2022). In section 5, we introduce the economic motive to *voluntary* migrate along the lines of a standard cost/benefit analysis; in this variant of the main model, the total number of new candidates to migration N becomes an endogenous variable, since these voluntary migrants also migrate irregularly with the help of smugglers.

The other incoming flow of candidates to migration is made of migrants pushed back in the different stages of the migration process who do not give up their migration project facing adversity.

Candidates to migration leave the area of origin either along a legal channel at a (small) exogenous rate σ, or through the illegal smuggling market.[9] The rate at which the candidate finds a smuggler has been defined in equation (4) as $g(\theta)$. Similarly, a smuggler who searches for a candidate to migration finds one at a rate $h(\theta)$ defined in equation (3).

A candidate to migration and a smuggler who meet each other enter a tacit "travel contract". The contract involves a negotiated smuggling fee w and the obligation for the smuggler to guide and support the journey of the migrant toward a destination country (i.e. provide the smuggling service).

After a successful match, in a next stage, the migrant-smuggler pair waits for an opportunity to leave the conflict area; when this opportunity materializes (at a rate a), they begin their dangerous journey from the origin area to the destination area.

Within the context of migration to the EU, the travel stage could be divided into a land and a sea steps. For the sake of parsimony we merge the two in a single block. During the land journey, matched smugglers and migrants can be stopped by local and border police in countries along their road at a rate η. In this case, migrants are sent back to their origin area, while smugglers are convicted. When they reach the southern border of the Mediterranean sea, smugglers board migrants on makeshift boats, and let them sail towards the destination area, with the responsibility of piloting being normally assigned to one of the passengers (Lyuten and Smialowski, 2021; McAuliffe and Laczko, 2016). For the migrants, the sea journey is extremely dangerous. Different reports point out to the outrageous situation where thousands of migrants die every year during the sea crossing (Achilli and Sanchez, 2017; EUFRA, 2019). In 2019, it is estimated that with approximately 124 000 Mediterranean arrivals to Europe, nearly 1 340 migrants died or went missing (UNHCR, 2020). To keep the model simple, we assume that smugglers have a zero probability to die on the road, and denote by δ the rate at which migrants can lose their life during the sea journey.

Not all the migrants in the travel stage will reach the destination area. Their project may also be deterred by other external shocks (natural events, unexpected conflicts, accidents, etc.). To account for all these external events, we assume that the journey to the destination succeeds at a rate λ.[10]

We also assume that the smuggler waits for the migrant's journey to end (either reaching the EU border, or unfortunately dying) before turning back to the origin area and starting searching for a new candidate to migration.

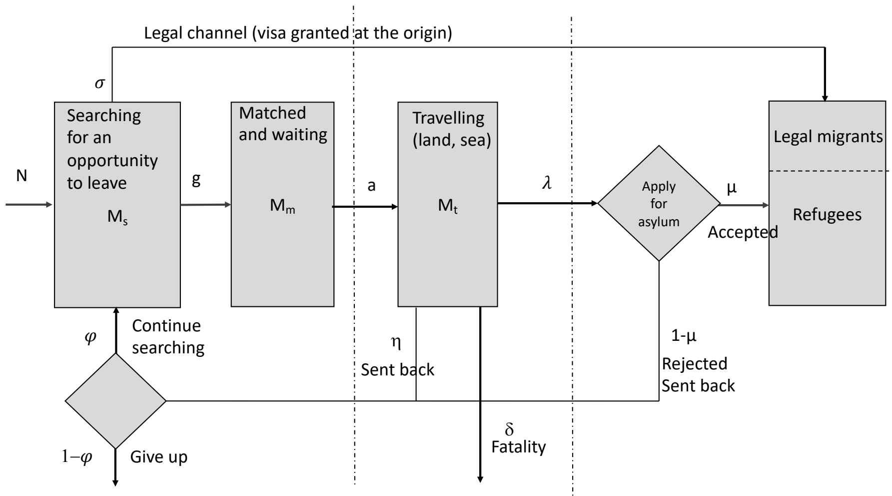
[9] We implicitly assume that candidates to migration simultaneously search for a smuggler and apply for a visa. Those who have the chance to obtain a visa will leave through the regular channel, the others will use the irregular channel.

[10] In a continuous time framework, λ allows us to take into account the fact that the duration of the journey may vary from a very few days to weeks or even years (European Commission, 2015b).

The last stage corresponds to processes that occur in the destination area (Europe). Once the migrants reach the European border of the Mediterranean sea, they apply for asylum. Because they travel without a visa, this mechanically makes them irregular migrants. Some of them have their asylum application rejected, while the others have their application accepted. We assume that the application is granted at a rate μ, and this rate is representative of the stringency of the EU asylum policy. For the sake of parsimony, we assume that those who have their application rejected are sent back and effectively return to the origin area; the return rate is then $1-\mu$.[11]

Among those who are returned to the destination country (both those stopped by the border police and those whose asylum application is rejected), some of the potential migrants are discouraged and abandon their migration project; the others start, one more time, to search for a smuggler. Some witnesses state that some migrants tried to cross border fifteen times or more.[12] Let φ denote the rate at which migrants continue searching.

Figure 1: Flow diagram for the candidates to migration



3.3 Flows and stocks of migrants and smugglers

The analysis in this paper focuses on the steady state equilibrium, wherein flows in and out of each state offset each other, i.e. $\dot{M}_s = \dot{M}_m = \dot{M}_t = 0$.

[11]An alternative interpretation might be that this parameter reflects the share of irregular migrants who manage to stay in the destination country. An additional parameter might allow us to differentiate between the migrants who see their asylum status denied and accept to be sent back, and those who manage to fall between the cracks and stay as irregular migrants in the destination area. To keep the number of parameters relatively small, we will not consider this latter case.

[12]See for instance The Economist, August 8, 2019, "Migrant arrivals in Italy have tumbled" or Deutche Welle, December 1, 2019, "Germany: Thousands of migrants return after deportation".

According to the flow diagram (Figure 1), the inflow of migrants searching for a smuggler is made up of N new candidates arriving every period from the conflict area, and of a proportion φ of the migrants who have either been caught by the border police during their journey (at rate η) or who have reached the destination country (at rate λ) but were denied asylum (at rate $1-\mu$).

All candidates to migration search for a smuggler, who can be found at rate $g(\theta)$, and apply for a visa, which can be granted at rate σ. The steady state condition for the pool of candidates to migration then implies:

$$\dot{M}_s = 0 \iff \underbrace{N + \varphi\left[\eta + \lambda\left(1-\mu\right)\right]M_t}_{\text{inflow}} = \underbrace{\left[g\left(\theta\right) + \sigma\right]M_s}_{\text{outflow}}. \tag{8}$$

Similarly, the flow diagram shows that migrants who found a smuggler then have to wait for an opportunity to undertake their journey, which occurs at rate a. The steady state condition for the pool of candidates who met a smuggler and now wait for an opportunity to leave implies:

$$\dot{M}_m = 0 \iff \underbrace{g\left(\theta\right)M_s}_{\text{inflow}} = \underbrace{aM_m}_{\text{outflow}}. \tag{9}$$

Finally, Figure 1 summarizes the fact that travelling migrants can be caught by the police at rate η, die during their sea journey at rate δ, or reach the destination country at rate λ. Those who reach the destination apply for asylum, which is either granted at rate μ or rejected at rate $1-\mu$. The steady state condition for the pool of travelling migrants then implies:

$$\dot{M}_t = 0 \iff \underbrace{aM_m}_{\text{inflow}} = \underbrace{\left(\delta + \eta + \lambda\right)M_t}_{\text{outflow}}. \tag{10}$$

Combining these flow equations, we obtain the expression of the mass of irregular migrants traveling to reach the destination country, M_t:

$$M_t = \frac{N}{\frac{\sigma}{g(\theta)}\left(\delta+\eta+\lambda\right) + \delta + \eta\left(1-\varphi\right) + \lambda\left[1-\varphi\left(1-\mu\right)\right]}. \tag{11}$$

The flow of irregular migrants reaching the destination area - a key variable of interest for policy purposes - is λM_t; it depends on the market tightness and on the policy parameters.

The first stage mass of candidates to migration (searching for a smuggler and applying for a visa) is then:

$$M_s = \frac{\delta+\eta+\lambda}{g\left(\theta\right)}M_t. \tag{12}$$

Finally, another variable of interest for policy purpose is the number of smugglers in the market.[13] Making use of $S_s = \theta M_s$ and $g\left(\theta\right) = \theta h\left(\theta\right)$, the number of active smugglers is given

[13] Policies aiming at controlling migration flows may focus not only directly on the number of migrants, but also on the number of smugglers.

by:[14]

$$S_s = \frac{\delta + \eta + \lambda}{h(\theta)} M_t. \tag{13}$$

This expression depicts a decreasing and concave relationship between the number of smugglers looking for a migrant S_s and the number of migrants searching for a smuggler M_s, similar to the Beveridge-curve in the standard labor market model.

3.4 Asset values

3.4.1 The asset value of a candidate to migration

Let us denote by V the asset value of a person living within the origin area, by V_s^M the asset value of a candidate to migration searching for a smuggler, by V_m^M the asset value of a matched migrant waiting for an opportunity to travel, and by V_t^M the asset value of a migrant during his/her journey.

Given the transition rates defined before, and denoting by r the interest rate, these asset values can be written as follows:

$$rV = b \tag{14}$$

$$rV_s^M = g(\theta)\left(V_m^M - V_s^M\right) + \sigma\left(Y - V_s^M\right) \tag{15}$$

$$rV_m^M = a\left[-w + \left(V_t^M - V_m^M\right)\right] \tag{16}$$

$$\begin{aligned} rV_t^M = {} & \delta\left(-D - V_t^M\right) + \eta\left[\varphi V_s^M + (1-\varphi)V - V_t^M\right] \\ & +\lambda\left[\mu Y + (1-\mu)\left(\varphi V_s^M + (1-\varphi)V\right) - V_t^M\right]. \end{aligned} \tag{17}$$

These expressions acknowledge that candidates to migration are subject to different types of frictions: it takes time to find a smuggler (at rate $g(\theta)$); once matched, it is necessary to wait for an opportunity to undertake the journey (at rate a)[15]; once they start travelling, the length of the journey is not given (it depends on the rate λ). The value of being a candidate to migration then also depends on the value of being matched with a smuggler, V_m^M, and on the value of undertaking the journey, V_t^M.

Before departure (or before taking the decision to leave), an individual has a benefit b.[16] In any case, it is worth being a candidate to migration if and only if $V_s^M \geqslant V$. In this first part of our analysis, where the focus is set on the behavior of forced migrants, we assume that this

[14] In the Cobb-Douglas case, replacing θ by S_s/M_s in this expression yields:

$$S_s = \left[\frac{(N - \sigma M_s)(\delta + \eta + \lambda)}{p(M_s)^\alpha \{\delta + \eta(1-\varphi) + \lambda[1 - \varphi(1-\mu)]\}}\right]^{\frac{1}{1-\alpha}}.$$

[15] Anecdotal evidence suggest that candidates to migration sometimes wait for years before undertaking the journey.

[16] A positive b can be interpreted as an income from work/home production and/or any humanitarian subsidy; a negative b reflects the fact that the individual's life is under threat.

condition is always fulfilled. In section 5, we will consider that, within the total population of that area, besides the forced migrants who will always strive to leave the conflict zones, some will decide to be candidates to migration if $V_s^M - V \geqslant z$, where z is a cost of leaving.[17] This cost-benefit analysis is a key characteristic of economic migration (Harris and Todaro, 1970; Borjas, 1989; Greenwood, 2021).[18]

As already mentioned, a candidate to migration applies and may be granted a visa at rate σ; this allows him/her to go and stay lawfully in the destination country where he/she enjoys the asset value of a permanent job Y (e.g. the discounted flow of his future income in the destination country). Thus, he/she obtains a capital gain equal to $Y - V_s^M$. He/she can also find a smuggler at rate $g(\theta)$; if the matching process is successful, he/she obtains a capital gain equal to $V_m^M - V_s^M$.

When matched, the migrant waits for an opportunity to start travelling, which materializes at rate a; he/she then obtains a capital gain equal to $V_t^M - V_m^M$ and has to pay the fee w. Based on evidence provided in section 2, we assume that the migrant pays to the smuggler a smuggling fee w. This fee is part of the smuggling contract, and its amount is negotiated at the time of the agreement. Quite often the fee is paid up-front, in full amount (Abdel Aziz et al., 2015). As mentioned earlier, sometimes a more sophisticated payment scheme can be implemented, to limit the scope for opportunistic behavior.[19] The cash-in-advance assumption implicitly requires that the migrant can afford to pay this fee; for so doing, he has sold assets, used his savings or borrowed from family, which are plausible assumptions in the case of asylum seekers, who liquidate all their local assets when they leave.[20]

On the road, the migrants and smugglers may be caught by the authorities at rate η. When caught, migrants are sent back to their origin country where they start looking for a smuggler at rate φ. Other migrants may die during the journey at rate δ; they then incur a large cost, denoted by D. Finally, the lucky ones reach destination at rate λ. Those who reach the borders of the EU are granted the asylum status at rate μ. This allows them to stay in the destination country where they enjoy the asset value of a permanent job Y; otherwise, they are returned to their origin country (where they start looking for a smuggler at rate φ).

3.4.2 The asset value of a smuggler

Let us denote by V_s^S the asset value of a smuggler searching for a candidate to migration, by V_m^S the asset value of a smuggler matched with a candidate before the start of the journey, and by V_t^S the asset value of a smuggler organizing the journey to the destination country. Such asset

[17] It is implicitly assumed that the cost of migration of forced migrants is null.

[18] See also Zenou (2009) for a detailed analysis of voluntary migration with frictions.

[19] Using a more sophisticated payment scheme would not change the basic structure of the model.

[20] Applied to a different context, Tamura (2010) assumes that the fee is paid only if the migrant has been smuggled as agreed.

values can be written as follows:

$$rV_s^S = -c + h(\theta)\left(V_m^S - V_s^S\right) \tag{18}$$

$$rV_m^S = a\left[(w - l) + \left(V_t^S - V_m^S\right)\right] \tag{19}$$

$$rV_t^S = \eta\left(-K - V_t^S\right) + \delta\left(V_s^S - V_t^S\right) + \lambda\left(V_s^S - V_t^S\right). \tag{20}$$

We assume that the smuggler who searches for a migrant incurs a fixed cost c (advertising his business, planning the best route to migrate and maintaining contacts along the route...), which might include a stigma of a person involved in illegal activities. When the smuggler is matched with a candidate to migration (at rate $h(\theta)$), he/she obtains a capital gain equal to $V_m^S - V_s^S$.

After a successful match, the smuggler waits for an opportunity to start travelling, which materializes at rate $a > 0$. Then, he/she undertakes the journey, which involves a cost l per migrant (transportation, guiding and escorting through irregular border crossing, shelter along the route, food, bribes, counterfeit documents...). As already mentioned, we assume that the migrant pays to the smuggler a smuggling fee w up-front, when the journey begins.

Once the journey has started, the smuggler and the migrant may be caught by the local and border police at rate η. If they are caught, the candidate to migration is sent back to his origin country, while the smuggler is sent to jail (he/she is pushed out of the smuggling business); this is tantamount to a cost $K > 0$ incurred by the smuggler. Otherwise, the migrant may die at rate δ or reaches the destination country at rate λ. In both cases, the smuggler can then continue his smuggling activities.

3.5 Free entry of smugglers

With respect to the recent migration flows to Europe, empirical evidence as presented in section 2 suggests that most of the smuggling activity is carried out by small businesses, run by largely independent and autonomous higher-level smugglers that compete between them to provide services to a limited number of candidates to migration (Abdel Aziz et al., 2015; Campana, 2018; Campana and Gelsthorpe, 2020).

We therefore represent smugglers as entrepreneurs, owners of "small firms" made up of a small number of relatives and close friends. These entrepreneurs in criminal activities can freely and rapidly enter the smuggling market; thus profit from smuggling is quickly driven down to zero. When a smuggler is convicted and pushed out of the smuggling business, another smuggler will enter the market, in keeping with the profit indifference condition.

The free entry assumption implies exhaustion of all rents, i.e.:

$$V_s^S = 0. \tag{21}$$

In this respect, the model in this paper can be seen as a variant of the "small firm" matching model in the labor market literature.

3.6 Smuggling fee determination

Information on the way the fees are negotiated or fixed by the smugglers is scarce. As mentioned in section 2, smugglers and migrants are in a business relationship that leaves room for a negotiated fee (European Commission, 2015b; UNODC, 2018). Smugglers have important reputation concerns which prevent full exploitation of the migrants. Actually, many studies have revealed a form of care toward the majority of migrants (Achilli and Sanchez, 2017; Achilli, 2018; Campana and Gelsthorpe, 2020), with of course exceptions to the rule.

To account for these elements, it seems sensible to model the fee negotiation process using the standard Nash bargaining solution (Nash, 1950), following a standard approach in the search and matching literature.

The total surplus to be shared between the matched smuggler and candidate to migration is:

$$\Sigma = \left(V_m^M - V_s^M\right) + \left(V_m^S - V_s^S\right). \tag{22}$$

How it is allocated between the smuggler and the migrant depends on the value of the fee w, which results from:

$$\max_w \left(V_m^M - V_s^M\right)^{1-\beta} \left(V_m^S - V_s^S\right)^{\beta}, \tag{23}$$

where $\beta \in (0,1)$ captures the relative bargaining power of the smugglers.

From the First Order Condition (FOC) combined with equations (15) to (20), we obtain:[21]

$$(1-\beta)\left(V_m^S - V_s^S\right) \quad = \quad \beta\left(V_m^M - V_s^M\right). \tag{24}$$

Accordingly, smugglers (resp. migrants) receive a share β (resp. 1-β) of the surplus Σ. Assuming free entry of smugglers $\left(V_s^S = 0\right)$, using the sharing rule (24) and the asset value equations (15) to (20), we can write the smuggling fee as:

$$w \quad = \quad (1-\beta)\left(l + \frac{\eta K}{r+\delta+\eta+\lambda}\right) + \beta\left(V_t^M - \frac{a+r}{a}V_s^M\right), \tag{25}$$

or equivalently:

$$\begin{aligned} w \quad = \quad & (1-\beta)\left(l + \frac{\eta K}{r+\delta+\eta+\lambda}\right) + \beta\left(\frac{\lambda\mu Y - \delta D + \left[\eta + \lambda(1-\mu)\right](1-\varphi)V}{r+\delta+\eta+\lambda}\right) \\ & -\beta V_s^M\left(\frac{r+\delta+\eta(1-\varphi)+\lambda\left[1-(1-\mu)\varphi\right]}{r+\delta+\eta+\lambda} + \frac{r}{a}\right). \end{aligned} \tag{26}$$

[21] Namely, the FOC to problem (23) writes:

$$(1-\beta)\frac{\partial\left(V_m^M - V_s^M\right)/\partial w}{V_m^M - V_s^M} \quad = \quad -\beta\frac{\partial\left(V_m^S - V_s^S\right)/\partial w}{V_m^S - V_s^S},$$

while equations (15) to (20) imply:

$$\frac{\partial\left(V_m^M - V_s^M\right)}{\partial w} = -\frac{\partial\left(V_m^S - V_s^S\right)}{\partial w} = -\frac{a}{a+r}.$$

The fee w is a weighted average between the smuggler's cost of providing his/her services and the migrant's net expected gain. Namely, due to matching frictions, a surplus is created when a candidate to migration and a smuggler meet. Nash bargaining gives rise to rent sharing and, as a result, migrants pay a share $(1-\beta)$ of the net expected costs incurred by smugglers for a journey, $l + \frac{\eta K}{r+\delta+\eta+\lambda}$, while smugglers capture a share β of migrants' net expected gain.

In the particular case where migrants have all the bargaining power, i.e. when $\beta = 0$, then the fee depends only on the smuggler's expected cost of a journey.[22] When smugglers have all the bargaining power, i.e. when $\beta = 1$, then the fee depends only on the migrants' net expected gain.

For $\beta \in)0,1)$, rent sharing between smugglers and migrants also implies that the fee depends negatively on migrants' outside option V_s^M as a higher outside option puts them in a better position to negotiate the fee and reduces the surplus to be shared.

In Appendix A.2, we show how directed search could provide an alternative modelling framework for the fee setting process. In this alternative framework, migrants have some control on the search process. More precisely, they choose which smuggler to pick, by trading off a higher fee against a shorter waiting time, as smuggler posting smaller (larger) fees will attract more (respectively fewer) migrants, who will have to wait in longer (shorter) queues before reaching the smuggler. Comparing the FOC associated with the program in Appendix A.2 with equation (24) above, it turns out that both sharing rules are equivalent when the Hosios condition $\beta = 1 - \alpha$ is met (in the Cobb-Douglas case). Although the two fee determination mechanisms are quite different in nature, they lead to a fee equation with similar properties.

We can now turn to the analysis of the equilibrium.

4 Equilibrium Analysis

In this section, we solve the model for the steady state equilibrium for a given number of candidates to migration. We proceed in three steps. First, we use the free entry condition to show how market tightness depends on the value of the smuggling fee. Second, the fee negotiation process allows to express the fee itself as a function of market tightness. Finally, we determine the equilibrium by taking into account both relationships, and study its properties. We present the case with endogenous migration decision in the next section. Policy implications of both cases are then discussed in section 6.

[22] Notice, however, that this is a partial equilibrium property: under free entry, the expected profit from smuggling activities and the smugglers' incentives to enter the market become nil in this case, as searching for migrants is costly while this yields no expected profit. Therefore, the market is not viable in such a case.

4.1 The smuggler free-entry condition

Under free entry of smugglers, equations (18) to (20) yield:

$$\underbrace{\frac{c}{h(\theta)}}_{\text{expected search costs}} = \underbrace{\frac{a}{a+r}\left(w-l-\frac{\eta K}{r+\delta+\eta+\lambda}\right)}_{\text{expected benefit}}. \tag{27}$$

Free entry implies that new smugglers enter the market until expected benefits from smuggling activities, V_m^S, equalize expected search costs, $\frac{c}{h(\theta)}$.

The free entry equation (27) implicitly defines a continuous and increasing relationship between the smuggling fee and the market tightness. All else equal, a higher fee w would attract more smugglers, thereby increasing θ.

Notice that the tightness θ moves down with the costs of providing smuggling services, c, l and $\frac{\eta K}{r+\delta+\eta+\lambda}$, which all tend to deter the entry of smugglers at given value of the fee. For opposite reasons, it moves up with parameter a: the reduction of the waiting time between a match and the beginning of a journey makes matches more profitable and therefore attracts more smugglers. Similarly, a fall in the time needed to find a migrant due to lower matching frictions p reduces expected search costs and will attract more smugglers, thereby increasing the tightness θ.

Thus, the market tightness θ increases with the fee w. At a given smuggling fee, it goes down with the costs of providing smuggling services, c, l, K and η, and up with parameters δ, λ, a and p. It does not directly depend on parameters D, μ, Y, φ, V, σ and β.

Let us now derive a second relationship between the market tightness and the smuggling fee.

4.2 Migrants' outside option and the fee equation

Combining the free entry condition (eq. 27) with the sharing rule (eq. 24) and the expression of the asset value of the searching migrant (eq. 15), and recalling that $g(\theta) = \theta h(\theta)$, we can express the migrants' outside option in the wage bargain, V_s^M, as a function of the market tightness θ:

$$V_s^M = \tfrac{1}{r+\sigma}\left(\tfrac{1-\beta}{\beta}c\theta + \sigma Y\right). \tag{28}$$

Replacing in the expression of the smuggling fee (eq. 26) and rearranging, the smuggling fee w can be written as a function of the ratio θ, as follows:

$$\begin{aligned} w = {} & (1-\beta)\left(l+\frac{\eta K}{r+\delta+\eta+\lambda}\right) + \beta\left(\frac{\lambda\mu Y - \delta D + [\eta+\lambda(1-\mu)](1-\varphi)V}{r+\delta+\eta+\lambda}\right) \\ & - \left(\frac{r+\delta+\eta(1-\varphi)+\lambda[1-(1-\mu)\varphi]}{r+\delta+\eta+\lambda}+\frac{r}{a}\right)\left[\beta\frac{\sigma Y}{r+\sigma}+(1-\beta)\frac{c\theta}{r+\sigma}\right]. \end{aligned} \tag{29}$$

The fee w is a continuous and decreasing function of θ: a tighter market (e.g. more searching smugglers relative to the number of searching migrants) puts each migrant in a better position to negotiate the fee, which then tends to decrease.

In Appendix A.3, we show that, at given tightness, the fee moves down with δ and D (which reduce the migrants' expected gain from migration), as well as with c (which increases the migrant's outside option). It moves up with μ and φ (which increase the migrants' expected gain from migration), as well as with l and K (which increase the smugglers' expected cost), and with a (which increases the surplus to be shared). The fee also moves up with the smugglers' bargaining power β (since increasing the smugglers' bargaining power implies that migrants get a lower share of the surplus) and with the asset value of staying in the origin country V (which increases the surplus to be shared).

A rise in Y has an ambiguous impact on the fee: it raises the migrants' final gain from migration and hence the surplus to be shared, but at the same time, it also raises their outside option in the bargain, which has the opposite effect. Interestingly, this total effect becomes unambiguously positive whenever σ tends to zero: the negative effect disappears in this case.

The impact of the rate η at which migrants are caught on the fee w is ambiguous: it has a positive impact on the expected cost of the smugglers, on the migrants' expected gain when they die on the road, are caught or denied asylum $\left(\frac{-\delta D+[\eta+\lambda(1-\mu)]\left[\varphi V_s^M+(1-\varphi)V\right]}{r+\delta+\eta+\lambda}\right)$, but a negative impact on the final discounted expected benefit from migration $\left(\frac{\lambda\mu Y}{r+\delta+\eta+\lambda}\right)$.

Similarly, the rate λ at which travelling migrants reach the destination country has an ambiguous impact on the fee w: it reduces the expected cost of the smugglers, which reduces the fee, but at the same time, it raises the migrants' gain from the journey, which increases the fee.

Finally, the rate σ at which candidates to migration get a visa has an ambiguous impact on the migrants' outside option V_s^M and hence on the fee w.

Thus, the negotiated fee w decreases with θ, as a tighter market puts the migrants in a better position to negotiate. At given market tightness, it goes down with δ, D and c, and up with l, K, μ, φ, V, a and β; Y, η, λ and σ have an ambiguous impact on w, while p does not have any.

4.3 The equilibrium

Definition. A steady state equilibrium of the smuggling market is a n-tuple (θ^*, w^*, M_s^*, M_m^*, M_t^*, S_s^*, S_m^*, S_t^*) such that: (i) the free entry condition (27) holds, (ii) the fee equation (29) is satisfied, (iii) the equilibrium numbers of migrants and smugglers at each step of the migration process, defined by equations (10) to (13), hold.

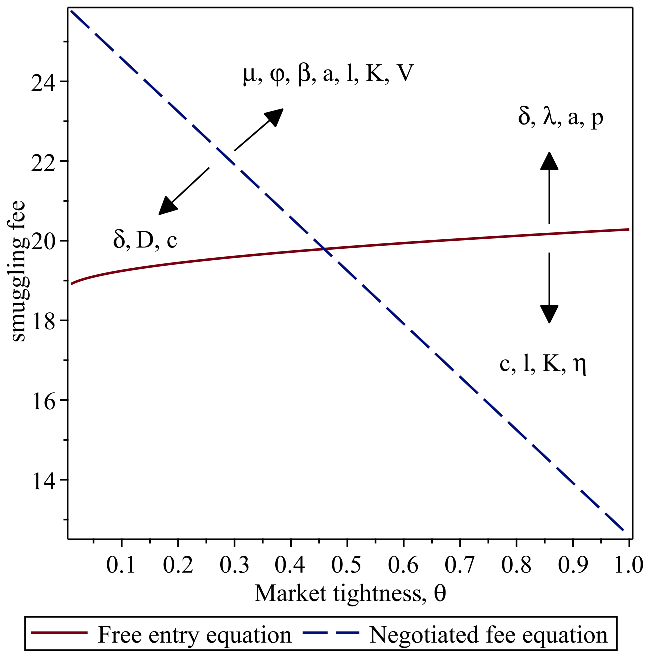
The market tightness. All these variables are themselves a function of the market tightness θ^*, which is the main unknown of the model. It can be determined as follows. Combining the free entry equation (27) with the smuggling fee equation (29), we obtain the equilibrium values of the fee w^* and of the market tightness θ^*.

The equilibrium, if it exists, is unique, as according to the first relationship, the tightness θ is increasing in the fee w, whereas according to the second one, the fee w is decreasing in θ.

Figure 2 provides a parametric draw of the two curves as defined in equations (27) and (29) and shows how each curve moves with the parameters.

An interior solution exists provided that the two curves cross each other, which requires that the surplus of a match is still positive when the market tightness tends to zero.

Figure 2: Equilibrium tightness and fee



Note: Plot parameters: $Y = 150$, $V = 5$, $K = 75$, $D = 1000$, $\alpha = 0.5$, $\beta = 0.5$, $\eta = 0.30$, $\lambda = 0.90$, $a = 1$, $\delta = 0.0005$, $\varphi = 0.95$, $r = 0.015$, $c = 1,5$, $l = 0.25$, $c = 1,5$, $\mu = 0.90$, $\sigma = 0,025$, $p = 1$. The numerical solutions are θ^{*}=0.46 and w^{*}=19.8.

Namely, inserting the fee equation (29) into (27), we write that the equilibrium tightness solves the free entry condition as follows:

$$\frac{c}{h(\theta^*)} = \beta\Sigma^*, \tag{30}$$

with:

$$\begin{aligned}\Sigma^* = \; & \frac{a}{a+r}\left[\left(\frac{\lambda\mu Y - \delta D + [\eta + \lambda(1-\mu)](1-\varphi)V}{r+\delta+\eta+\lambda}\right) - \left(l + \frac{\eta K}{r+\delta+\eta+\lambda}\right)\right] \\ & - \frac{a}{a+r}\left[\frac{r+\delta+\eta(1-\varphi)+\lambda[1-(1-\mu)\varphi]}{r+\delta+\eta+\lambda} + \frac{r}{a}\right]\left[\frac{\sigma Y}{r+\sigma} + \frac{1-\beta}{\beta}\frac{c\theta^*}{r+\sigma}\right]. \end{aligned} \tag{31}$$

This expression can be interpreted in the following way: given the fee determination process studied in subsections (3.6) and (4.2), smugglers receive a share β of the surplus Σ^* defined by equation (31), which determines their expected profit when entering the market. Free entry then implies that smugglers enter until all profit opportunities are exhausted, i.e. until expected profits equalize expected cost of searching a migrant to smuggle.

Considering (30) and (31), we see that an equilibrium exists provided $\lim_{\theta*\to 0} \Sigma^* \geqslant 0$, which yields the following parametric condition:[23]

$$\left(\frac{\lambda\mu Y - \delta D + [\eta + \lambda(1-\mu)](1-\varphi)V}{r+\delta+\eta+\lambda}\right) - \left(l + \frac{\eta K}{r+\delta+\eta+\lambda}\right) - \left[\frac{r+\delta+\eta(1-\varphi)+\lambda[1-(1-\mu)\varphi]}{r+\delta+\eta+\lambda} + \frac{r}{a}\right]\left[\frac{\sigma Y}{r+\sigma}\right] \geqslant 0. \quad (32)$$

Thus, we can write the following proposition.

Proposition 1 ***Existence of the equilibrium smuggling market tightness*** θ^****.***
A unique equilibrium smuggler per potential migrant ratio $\theta^* > 0$ exists under condition (32); it is the solution of equation (30), with the surplus Σ^* defined by equation (31).

We can now study the comparative statics properties of the model.

4.4 Key comparative statics

As shown in Appendix A.4, in the equilibrium, the ratio of smugglers per potential migrant θ^* is increasing in the travel opportunity rate (a) which raises the size of the expected surplus Σ^* and in the scale parameter of the matching function p, which reduces expected search costs $\frac{c}{h(\theta*)}$. It is also increasing in the continuation rate (φ), the journey ending rate (λ), the asylum-status success rate (μ) and with the asset value of staying V, which all increase the surplus to be shared. The positive impact of V deserves some additional comment: namely, from equation (31), we see that, absent the push-back phenomenon, the positive impact would collapse. This effect is thus clearly related to the push-back phenomenon emphasized in this paper. To our knowledge, this is an original result compared to the literature on the behavior of forced migrants.

Tightness θ^* is decreasing in the fixed and variable costs of smuggling activities (c and l) which reduce the profitability of being a smuggler, the intertemporal cost of death (D) and the cost of being convicted (K), which all reduce the surplus to be shared.

Its variations with regards to the intertemporal value of migration (Y), the arrest rate (η) and the death rate (δ) are ambiguous as they all have a twofold effect on the surplus size.

The impact of the rate of getting a visa (σ) deserves some additional comments. First, since it has an ambiguous impact on the migrants' outside option (V_s^M), its impact on the equilibrium tightness is ambiguous as well. Second, absent the visa policy ($\sigma = 0$), the impact of Y on the market tightness would unambiguously be positive.

Finally, the impact of the relative bargaining power of the smugglers, β, is positive, as a rise in their relative bargaining power will make smuggling more attractive and will thus imply an additional entry of smugglers.

[23] Intuitively, this condition ensures that the free entry curve stemming from (27) starts below the curve resulting from the fee equation (29) in the (w, θ) plan. More formally, we have that $\lim_{\theta*\to+\infty}\left(\frac{c}{h(\theta*)} - \beta\Sigma^*\right) = +\infty$, while $\lim_{\theta*\to 0}\left(\frac{c}{h(\theta*)} - \beta\Sigma^*\right) \leqslant 0$ under condition (32). Therefore, if this condition is met, by the intermediate value theorem, there exists a $\theta^* \geqslant 0$ solving $\frac{c}{h(\theta*)} = \beta\Sigma^*$, i.e. the two curves cross.

These equilibrium properties of the smuggling market tightness are summarized in the following proposition.

Proposition 2 ***Properties of the equilibrium smuggling market tightness*** θ^***.**
The equilibrium smuggling market tightness θ^* *increases with* λ, μ, φ, V, a, β *and* p*; it decreases with* c, l, K *and* D*; its variations with respect to* η, δ, Y *and* σ *are ambiguous.*

With knowledge of these properties, we can study the comparative statics properties of the equilibrium smuggling fee:

Proposition 3 ***Properties of the equilibrium smuggling fee*** w^***.**
The equilibrium smuggling fee w^* *increases with* l, K, μ, φ, V *and* β*; it decreases with* D *and* p*; its variations with respect to* η, δ, λ, Y, a *and* σ *are ambiguous. The fee decreases (increases) with* c *provided* $\epsilon_{\theta*/c} > -1 (< -1)$*, i.e. the elasticity of the tightness with respect to* c *is not too large (is large).*

Calculations are presented in Appendix A.5.

Variables θ^* and w^* are essential for determining the equilibrium of this market. However, the main purpose of the analysis is to reveal the consequences of various policy measures on a small set of key variables of interest for policy-making:

(1) the migrants' welfare V_s^{M*} as defined in equation (28),

(2) the number of irregular migrants reaching the EU border λM_t^* resulting from equation (11),

(3) the total number of active smugglers S_s^* as defined in equation (13).

These variables are functions of parameters and of the equilibrium tightness and smuggling fee (θ^*, w^*), which also depend on the parameters of the problem. A change in parameters has therefore a direct and an indirect effect on the policy variables.

Table 1 summarizes the total effects of the parameters of our model on those variables in the case where there are only forced migrants (calculations are presented in Appendix A.6 to A.9).[24] For many parameters and variables, the signs are clearly identified.

In section 6, we provide numerical exercises, aiming to provide more intuition about these results, and particularly on the impact of policies.

[24] In section 5, we study how taking into account economic migrants impact these comparative statics.

Table 1: Comparative static results (in the forced migration case)

Parameter		Tightness θ^*	Smug. fee w^*	Smug. contact rate $h(\theta^*)$	Mig. welfare V_s^{M*}	Incoming irr. mig. λM_t^*	Smugglers S_s^*
Fixed cost	c	-	?	+	-	-	-
Variable cost	l	-	+	+	-	-	-
Arrest rate	η	?	?	?	?	?	?
Convicted penalty	K	-	+	+	-	-	-
Death rate	δ	?	?	?	?	?	?
Death penalty	D	-	-	+	-	-	-
Ending rate	λ	+	?	-	+	?	?
Asylum-status rate	μ	+	+	-	+	?	?
Migration value	Y	?	?	?	?	?	?
Continuation rate	φ	+	+	-	+	+	+
Home value	V	+	+	-	+	+	+
Travel opportunity rate	a	+	?	-	+	+	+
Legal migration rate	σ	?	?	?	?	?	?
Smugglers bargaining power	β	+	+	-	?	+	+
Matching efficiency	p	+	-	?	+	+	?

5 The specific case of economic migrants

So far, we have assumed that the flow of new candidates to migration is a constant, driven essentially by external factors, such as war, conflicts, natural catastrophes, that let residents of those areas no choice but to leave (forced migration). Their economic trade-off was limited to the bare negotiation of the fee with the smuggler.

In the case of voluntary or economic migration, a first cost-benefit analysis intervenes at the initial stage of the migration process. The model can be extended to incorporate this additional decision level. In this section, we sketch one possible modelling choice, allowing us to endogenize the flow of new candidates to migration, N.

5.1 Endogenizing the migration decision

While forced migrants have no choice but to leave areas where their life comes under threat, in many cases migration is driven by more materialistic considerations. In this perspective, individual migration decision is motivated, to a large extent, by the search for better economic opportunities (Harris and Todaro, 1970; Borjas, 1989; Greenwood, 2021).

The return to migration is the same for forced and voluntary migrants. As seen in the previous section, it is equal to $V_s^M - V$.

However, in this section, we assume that voluntary migrants are heterogeneous with respect to a *cost of migration* z. This cost includes all dimensions of disutility of migration such as abandoning his/her family, friends and even the local traditions and social environment. Let us further assume that the cost of migration z is distributed across the population of potential economic migrants with probability density function (PDF) ψ and cumulative density function (CDF) Ψ, defined on the interval $(0, z_{max})$.

In line with traditional literature on voluntary migration, an individual decides to migrate (for economic reasons) if the gains associated to migration are higher than the cost, i.e., provided that:

$$V_s^M - V \geqslant z. \tag{33}$$

We can then define the threshold cost $\overline{z}$ as the cost of an individual indifferent between migrating or staying. It is defined by:

$$\overline{z} = V_s^M - V. \tag{34}$$

Such a threshold is related to the equilibrium tightness and to the parameters of our model, as equation (28) implies:

$$\overline{z} = \frac{1}{r+\sigma}\left(\frac{1-\beta}{\beta}c\theta^* + \sigma Y\right) - V, \tag{35}$$

where θ^* is still determined by the free entry equation (30).

The number of economic migrants $NE(\overline{z})$ can then be defined as:

$$NE(\overline{z}) = L\Psi(\overline{z}), \tag{36}$$

where L is the population of potential economic migrants in the country of origin (an exogenous variable). The number of economic migrants is increasing in $\overline{z}$.

The number of forced migrants being given by NR, the total number of new candidates to migration, $N(\overline{z})$, is now given by the sum of the numbers of forced and voluntary migrants, i.e.:

$$N(\overline{z}) = NR + NE(\overline{z}). \tag{37}$$

Furthermore, the proportion of economic migrants among the candidates to migration can be defined as:

$$\phi_e(\overline{z}) = \frac{NE(\overline{z})}{NR + NE(\overline{z})} = \frac{L\Psi(\overline{z})}{N(\overline{z})}. \tag{38}$$

The total number of candidates to migration as well as the share of economic migrants are increasing in $\overline{z}$:

$$\frac{d\phi_e(\overline{z})}{d\overline{z}} = \frac{NR}{N(\overline{z})^2}\frac{dNE(\overline{z})}{d\overline{z}} \geqslant 0. \tag{39}$$

5.2 The impact of policies on the threshold cost of migration

We can then investigate the impact of the previous policies on the threshold cost $\overline{z}$, and thus on the number of economic migrants, the total number of candidates to migration and the share of economic migrants among them. To begin with, the comparative statics properties of the threshold $\overline{z}$ are summarized by the following proposition (calculations are presented in Appendix A.10) and in Table 2.

Proposition 4 ***Properties of the threshold cost of migration $\overline{z}$.***
The threshold cost of migration $\overline{z}$ is increasing in λ, μ, φ, a and p;
it is decreasing in c, l, K and D;
it is increasing (resp. decreasing) in β when $\alpha(\theta^*) \leqslant 1-\beta$ (resp. $\geqslant 0$);
the impact of Y is positive when $\sigma = 0$, and ambiguous otherwise;
the impact of η, δ, V and σ is ambiguous.

Table 2: Comparative static results (in the voluntary migration case)

Parameter		Nbr. of economic migrants NE^*
Fixed cost	c	-
Variable cost	l	-
Arrest rate	η	?
Convicted penalty	K	-
Death rate	δ	?
Death penalty	D	-
Ending rate	λ	+
Asylum-status rate	μ	+
Migration value	Y	?
Continuation rate	φ	+
Home value	V	?
Travel opportunity rate	a	+
Legal migration rate	σ	?
Smugglers bargaining power	β	?
Matching efficiency	p	+

An increase in parameters λ, μ, φ, a and p increases the market tightness θ^* (see Proposition 2) and hence, the return from migration. Quite on the contrary, a rise in c, l, K and D makes the smuggling market less attractive, and therefore reduces both the tightness and the return from migration. The impact of the smugglers' bargaining power β on the incentive to migrate is twofold: it directly tends to reduce the candidates to migration's expected utility, but it also raises the market tightness due to more entry of smugglers, which has the opposite effect. As usual in search and matching models, the size of each effect depends on the comparison between the migrants' bargaining power $(1-\beta)$ and the elasticity of the matching function α.

The impact of a rise in Y is ambiguous in the presence of a visa policy ($\sigma > 0$), as the impact of this parameter on market tightness is ambiguous in such a case, while it would be positive, absent the visa policy.

The impact of parameters η, δ and σ on the market tightness being ambiguous (see Proposition 2), all those parameters have an *a priori* ambiguous impact on the return from migration. Finally, an increase in V has an ambiguous effect of the incentives to migrate, as it both increases the market tightness (and thus the return from migration) and the value of staying in the origin country.

In the next section, we provide numerical results to illustrate the impact of the various policies on the numbers of migrants and smugglers, considering the cases of forced and voluntary migration.

6 Discussion and policy implications

In this section, we investigate the policy implications of our model. We first discuss the relationship between the various policies implemented to fight against irregular migration and the main parameters of our model, and then provide numerical experiments. For each policy, we proceed in two steps: (i) we first focus on the impact of policies on forced migrants only, and (ii) we then investigate their impact on economic migrants.

6.1 Policies and parameters

As mentioned in section 2, the EU governments of main migrant destination countries and the European Commission aim at keeping flows of irregular migration under control by means of various policies. Successful implementation of these policies requires a strong cooperation of the governments of transit countries and, when the situation allows it, of origin countries.

The dynamic framework developed in this paper allows us to study the consequences of these policies not only on the smuggling fee and the stocks of migrants, but also on migrants intertemporal welfare, the flow of incoming migrants and the number of smugglers, in a context where pushed-back migrants account for an important part of the candidates to migration.

EU migration policies can be classified as:

(1) internal measures that impact migrants' expected payoff from migration conditional on having reached the EU borders;

(2) actions aiming at making smuggling a high-risk low-profit activity; these policy measures involve cooperation with governments of both origin and transit countries;

(3) humanitarian measures, providing incentives for candidates to migration to abandon the migration project, by improving their living standard at home.

The theoretical model allowed us to infer several unambiguous effects as summarized in Table 1. However, several effects rely on complex relationships and cannot be signed. Also, the theoretical analysis has little to say about the sensitivity of the key variables to changes in parameters.

To address this issue, in the following section, we provide several numerical simulations. We assume a Cobb-Douglas matching function, as introduced in equation (5). Parameters are chosen as follows. The bargaining power is such that the surplus from matching is equally divided between the smuggler and the candidate to migration. Following the common practice in the matching literature, the Hosios (1990) condition is assumed to hold, which implies that $\beta = \alpha = 0.5$.

In the benchmark case, the migrant's payoff from reaching the destination country and being granted the asylum status is assumed to be thirty times as high as the migrant's permanent income in his/her origin country ($Y = 30V$), a ratio in line with the ratio between the average GDP/capita in the EU and the average GDP/capita of many developing countries in the Horn of Africa and Middle East. The smuggler's penalty if he/she is caught and convicted is quite high ($K = Y/2$); the probability of being caught is set at 30%.[25]

To obtain an indication about the flows of incoming migrants and the number of smugglers, we must bring into the picture the number of new candidates to migration per period, N. In the case where this number is exogenous (forced migration only), we set it to a "normalized" $N = 1000$ individuals.[26]

When the simulation allows for an endogenous number of migrants to include a proportion of economic migrants, the flow of new migrants per period is made up of both forced and voluntary migrants, $N = NR + NE$.

Among the whole set of potential economic migrants, will actually migrate (NE) those with a migration cost z below the threshold cost $\overline{z}$. For our benchmark parameters, using equation (34), we obtain $\overline{z} = 105.96$. Furthermore, we assume that the migration cost is uniformly distributed in the interval $(0, z_{max})$. To carry on the simulation, we introduce as additional parameters the potential population of economic migrants $L = 20000$[27] and the upper bound of the uniform distribution $z_{max} = 21192$. We obtain, in the benchmark case, $NE = L * (\overline{z}/z_{max}) = 100$. We also set the number of forced migrants to $NR = 900$, to obtain the same total number $N = 1000$ as in the exogenous migration case (for the benchmark parameters).

These parameters were chosen so that the total population of candidates comprises $\phi_e = 10\%$ of economic migrants. This value makes sense in the context of massive arrivals of forced migrants (for instance, from Syria in 2015). The rejection rate of asylum application (at that time) can be seen as a proxy for the share of economic migrants among irregular migrants.[28]

For the remaining parameters, we choose values that make economic sense, without resorting to a precise calibration, which would require many observations which, unfortunately, are not available in these opaque markets. Notice, however, that our numerical exercises allow for some variations of these parameters, providing some intuition about their respective quantitative impact.

Parameter values for the benchmark are summarized in Table 3.[29] The equilibrium variables as obtained for these parameters are displayed in the first column of Table 4.

[25] Frontex (2018) reports that approximately 700.000 migrants applied to enter the EU in 2017. During the same period, a bit more than 200.000 detections of illegal boarder crossings were reported, representing about 30% of applications.

[26] This may be thought of as roughly corresponding to the peak of the number of migrants from Syria in the 2010s (in thousands).

[27] Corresponding roughly to the population in Syria at the beginning of the conflict in the early 2010s (in thousands).

[28] Obviously, the institution in charge of granting the asylum status in the destination country can make mistakes in addressing asylum claims. The underlying assumption is that type 1 and type 2 errors (rejecting a claim made by a refugee vs. accepting a claim by an economic migrant) globally offset each others.

[29] Figure 2 uses the same benchmark parameters.

Table 3: Parameter values in the benchmark case

$c = 1, 5$	$l = 0.25$	$\eta = 0.30$	$K = 75$
$\delta = 0.0005$	$D = 1000$	$\lambda = 0.90$	$\mu = 0.90$
$Y = 150$	$\varphi = 0.95$	$V = 5$	$a = 1$
$\sigma = 0, 025$	$\beta = 0.5$	$p = 1$	$\alpha = 0.5$
	$r = 0.015$	$N = 1000$	

6.2 Policy consequences

6.2.1 Internal measures: visa, asylum and labour market policies

Visa policy. The rate of visas granted to candidates to migration (σ) is an important policy parameter, under the control of EU member states. The effect on the main equilibrium variables of changing σ could not be determined analytically, which justifies the use of numerical simulations.

Simulations presented in the upper pane of Table 4 reveal the consequences of a small increase in the rate of official visas from 2.5% to 4%. We distinguish the case of N exogenous (forced migration only) and of N endogenous (forced and voluntary migration).

In the exogenous N case, an increase in σ increases the flow of regular migrants and, at the same time, reduces the flow of irregular migrants. While these two effects are quite trivial, it should be emphasized that the total number of migrants (regular and irregular) declines: the decrease in the number of irregular migrants is higher than the increase in regular migrants.

Furthermore, with less migrants tempted to pay the smuggling fee, the number of smugglers is drastically cut. Finally, this policy not only helps curbing irregular migration but it also improves migrants' welfare.

Turning to the endogenous N case, while the impact of a change in the rate of visas granted to candidates (σ) on the incentives to migrate is ambiguous in the formal analysis (as shown in Proposition 4), our simulations suggest that it has a positive effect on the threshold cost $\bar{z}$ and might thus have the undesirable effect of increasing the number of economic migrants. Therefore, the proportion of economic migrants among the candidates to migration is likely to increase with the parameter σ.

Such results are in line with those already obtained by Auriol and Mesnard (2016): an extended visa policy would undermine the smuggling market; it would lead to an increase in the numbers of legal and economic migrants but to a decrease in the flows of forced migrants. In the end, however, in our simulations, the total number of migrants does not increase.

Asylum policy. In all EU countries, some voices call for new restrictions on asylum rights, which is tantamount to a reduction in μ. As mentioned in the introduction, in 2020 the European Commission developed a new framework (The Pact on Asylum and Migration) to improve cooperation with countries of origin, in order to smooth the process of sending back migrants who do not qualify for the asylum status; this may also imply a decrease in parameter μ.

The reasoning behind these calls relies on a "first-order" effect, according to which, denying the asylum right should deter migrants from leaving in the first stage. This line of reasoning does not take into account the fact that many of the pushed-back migrants will try to migrate again, and will do so several times. In this case, a higher rejection rate only beefs up the flow of incoming migrants, puts additional strain on border control and asylum application bodies, and ultimately nourishes the fears of those calling for tougher immigration policies.

Our simulation reveals a puzzling pattern, grounded in the send-back and return dynamics. As long as the acceptance ratio is above 70 %, any further reduction is only increasing the flows of irregular migrants. To some extent, it is more efficient to have a 100 % acceptance rate rather than a 70 % one, as shown in Figure 3. On the other hand, a very strict asylum regime might destroy the equilibrium of this market, with hard to foresee consequences. Our result contrasts with the work of Piguet (2020) who claims that several changes leading to a higher rate of success for asylum seekers explain, at least partly, the surge in irregular migration to Europe: the broadening of the definition of refugee in European legislation (at least before 2016), the judicialization of the asylum-related procedures, and the fact that asylum seekers have much higher chances to be granted the refugee status are among the main explanations to the increase in the number of asylum seekers to Europe.

Table 4 also presents the effect of the reduction in μ on the other variables of interest. An increase in the asylum rejection rate has a strong negative effect on the number of active smugglers. All the other effects are in line with the effects revealed in the theoretical part.

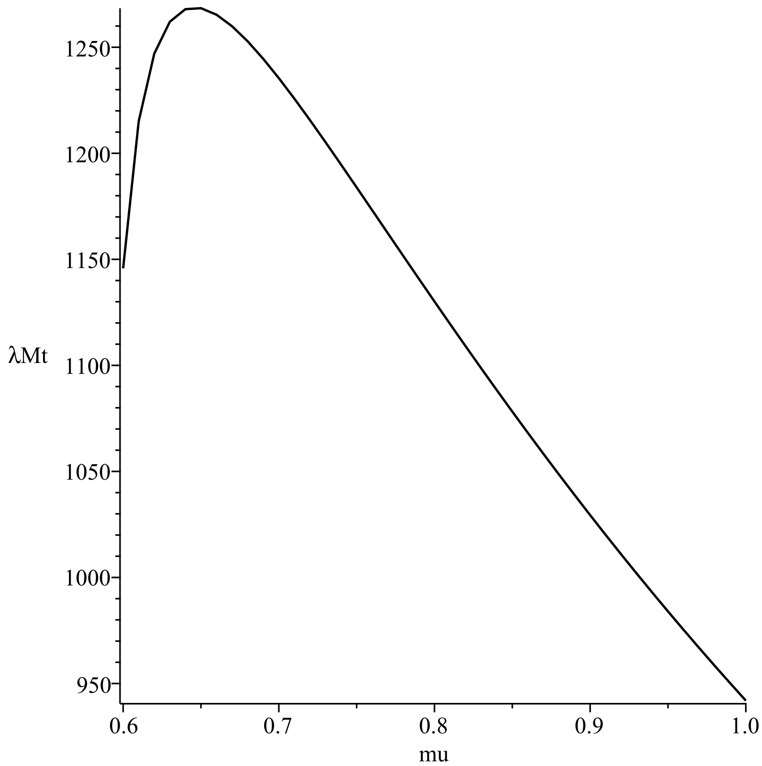
Such results can be complemented by investigating the impact of such a policy on the share of voluntary migrants in the endogenous N context. Simulations show that, consistently with Proposition 4, a more restrictive asylum policy (reduction in μ) will reduce the threshold migration cost $\overline{z}$ and thus the number and the share of economic migrants in the total number of migrants reaching the EU borders.

Table 4: Simulation results for internal policies

		Benchmark (1)	(2)	(3)	(4)
	Visa policy	$\sigma = 0.025$	$\sigma = 0.03$	$\sigma = 0.035$	$\sigma = 0.04$
Tightness θ^*		0.459	0.341	0.23	0.12
Smuggling fee w^*		19.8	19.65	19.49	19.26
Smuggler contact rate $h(\theta^*)$		1.47	1.71	2.1	2.88
Migrants welfare V_s^{M*}		110.96	111.4	111.8	112.4
Exogenous $(N = 1000)$					
Incoming irregular migrants λM_t^*		1029	1009	980	929
Legal migrants σM_s^*		51	69	96	142
Total migrants $\lambda M_t^* + \sigma M_s^*$		1080	1078	1076	1071
Smugglers S_s^*		930	786	623	430
Endogenous $(NR = 900, NE^*)$					
Economic migrants NE^*		100	100,38	100,8	101,3
Incoming irregular migrants λM_t^*		1029	1010	981	931
Legal migrants σM_s^*		51	69	96	143
Total migrants $\lambda M_t^* + \sigma M_s^*$		1080	1079	1077	1074
Smugglers S_s^*		930	786	624	431
	Asylum policy	$\mu = 0.90$	$\mu = 0.80$	$\mu = 0.70$	$\mu = 0.60$
Tightness θ^*		0.459	0.334	0.187	0.02
Smuggling fee w^*		19.8	19.64	19.42	18.98
Smuggler contact rate $h(\theta^*)$		1.47	1.72	2.31	7.1
Migrants welfare V_s^{M*}		110.96	106	100.7	94.5
Exogenous $(N = 1000)$					
Incoming irregular migrants λM_t^*		1029	1130	1235	1146
Smugglers S_s^*		930	872	712	216
Endogenous $(NR = 900, NE^*)$					
Economic migrants NE^*		100	95,6	90,36	84,46
Share of economic migrants ϕ_e^* (%)		10.0	09.6	09.1	08.6
Incoming irregular migrants λM_t^*		1029	1125	1223	1128
Smugglers S_s^*		930	868	705	212
	Labour policy	$Y = 150$	$Y = 175$	$Y = 200$	$Y = 220$
Tightness θ^*		0.459	0.653	0.848	1.01
Smuggling fee w^*		19.8	19.91	20.16	20.28
Smuggler contact rate $h(\theta^*)$		1.47	1.23	1.08	0.996
Migrants welfare V_s^{M*}		110.96	133.86	156	175
Exogenous $(N = 1000)$					
Incoming irregular migrants λM_t^*		1029	1038	1043	1046
Smugglers S_s^*		930	1119	1282	1400
Endogenous $(NR = 900, NE^*)$					
Economic migrants NE^*		100	121	143	161
Share of economic migrants ϕ_e^* (%)		10	12	13.7	15
Incoming irregular migrants λM_t^*		1029	1060	1089	1110
Smugglers S_s^*		930	1142	1338	1485

Note: Column (1) reports benchmark results, with parameters values summarized in Table 3. Each block of the table provides the results obtained for different internal policies. The exogenous N case applies to forced migration only, while the endogenous N case refers to the case of voluntary and forced migration.

Figure 3: Number of irregular migrants reaching borders depending on the stringency of the asylum policy



Note: Simulation in the exogenous N case. Parameters values are summarized in Table 3.

Labor market policy. EU authorities can impact the income a migrant may expect to earn if he/she is granted the asylum status through a couple of restrictions and incentives, such as creating programs promoting migrant integration and raising their employability, or by measures aiming at fighting discrimination in hiring and pay.

The theoretical analysis did not allow us to determine the effects of changes in Y on the equilibrium variables (Table 1). Simulation results in the lower pane of Table 4 allow us to provide some intuition about these consequences. It turns out that more generous labor market integration programs that are beneficial to migrants will result in more irregular migrants, but this also improves their welfare. On the other side of the market, more smugglers enter this market, and obtain a higher fee, an obviously undesirable consequence of this policy.

Notice that we have assumed that migrants who are denied the refugee status are returned to their country of origin. If some of them manage to stay in the country as now illegal migrants, measures against irregular employment (stricter controls, higher sanctions for the employers) might also have a (negative) impact on the expected economic gains associated with irregular migration, which could be interpreted as a lower permanent income Y (Orrenius and Zavodny, 2015; Borjas and Cassidy, 2019; Guriev et al., 2019). In 2021, the European Commission adopted a new directive for fighting the hiring of irregular migrants.

Finally, our simulations show that increasing the expected income of migrants implies an increase in the share of voluntary migrants. Proposition 4 established that increasing Y has an ambiguous impact on the incentives to migrate for economic reasons. However, in our numerical simulation, the impact of such a policy on the return from migration is unambiguously positive, as it increases the market tightness. This results in a higher number of candidates to migration for economic reasons in line with standard results in the literature on voluntary migration.

Our results are in line with those of Djajić and Vinogradova (2013, 2014) who find that a decrease in the expected asset value of migration decreases debt-bonded migration. They may also be related to the findings of Djajić and Vinogradova (2019), stressing that an increase in the expected asset value of migration increases legal voluntary migration. Contrary to our results, Tamura (2010, 2013) finds that decreasing the asset value from migration through increasing inland apprehension would increase the number of smugglers in the case of perfect information, while it would have no impact in the case of imperfect information.

6.2.2 Making smuggling a high-risk, low-profit activity

Within this category of policy measures, increasing border control and police anti-smuggling actions in both origin and transit countries can: *(i)* directly deter locals from entering the smuggling business by increasing the direct costs of smuggling (c and l), *(ii)* increase the penalty incurred by the smugglers when caught and convicted (K), via the judicial system, *(iii)* decrease the opportunities to start the journey (equivalent of decreasing the parameter a), thanks to a raise in the number of patrols and improvements in technology used to detect migrants, *(iv)* throw sand in the matching process, mainly by blocking informal publicity and communication (tantamount to reducing p), *(v)* set up restrictions that would increase the duration of the journey, which is tantamount to a lower λ, through restrictions of all kinds forcing smugglers to follow longer routes, such as building physical obstacles (fences, walls), and finally, *(vi)* increase the likelihood of being caught by the police during the journey (more border officers, better monitor equipment), equivalent to increasing η. The effects of parameter changes on the variables of interest might differ whether we consider the case of forced migration only, or we also allow for some voluntary migration.

Forced migration The theoretical analysis allowed us to infer, for many parameters, what their effect on policy variables could be (see Table 1). In general, measures that increase the costs of smuggling would deter smugglers entry, and reduce the flow of incoming migrants.

However, the theoretical analysis could not determine all the effects. In particular, we could not determine the effect of increasing the matching frictions (lower p) and pushing smugglers toward longer routes (lower λ).

Simulations presented in the "Exogenous N" pane of Table 5 show that these deterrence policies can also efficiently cut irregular migration. A reduced matching efficiency (lower p) brings about a paradoxical outcome, where less irregular migrants arrive, albeit the number of smugglers increases.

Numerical simulations reveal that, by contrast with the official visa policy, these measures also entail a reduction of migrants' welfare as they lead to a reduction in market tightness and a rise in the smuggling fee.

Table 5: Simulation results for cooperation policies

	Benchmark (1)	(2)	(3)	(4)
Increase in c, l or K		$c = 2$	$l = 0.50$	$K = 80$
Tightness θ^*	0.459	0.336	0.45	0.41
Smuggling fee w^*	19.8	19.94	20.03	20.98
Smuggler contact rate $h(\theta^*)$	1.48	1.72	1.49	1.55
Migrants welfare V_s^{M*}	110.96	110.6	110.63	109
Exogenous ($N = 1000$)				
Incoming irregular migrants λM_t^*	1029	1021	1029	1026
Smugglers S_s^*	930	789	921	884
Endogenous ($NR = 900, NE^*$)				
Economic migrants NE^*	100	99.6	99.7	98.8
Share of economic migrants ϕ_e^* (%)	10.0	09.9	09.9	09.8
Incoming irregular migrants λM_t^*	1029	1020	1028	1025
Smugglers S_s^*	930	789	920	882
Decrease in a, p or λ		$a = 0.75$	$p = 0.75$	$\lambda = 0.75$
Tightness θ^*	0.459	0.439	0.435	0.305
Smuggling fee w^*	19.8	19.8	20.1	22.21
Smuggler contact rate $h(\theta^*)$	1.48	1.51	1.51	1.81
Migrants welfare V_s^{M*}	110.96	110.23	110	105.2
Exogenous ($N = 1000$)				
Incoming irregular migrants λM_t^*	1029	1028	1010	1011
Smugglers S_s^*	930	909	1186	782
Endogenous ($NR = 900, NE^*$)				
Economic migrants NE^*	100	99.3	99.1	94.6
Share of economic migrants ϕ_e^* (%)	10.0	09.9	09.9	09.5
Incoming irregular migrants λM_t^*	1029	1028	1009	1005
Smugglers S_s^*	930	909	1185	778

Note: Column (1) reports benchmark results, with parameters values summarized in Table 3. The exogenous N case refers to the case of forced migration only, while the endogenous N case refers to the case of voluntary and forced migration.

The effect of a change in the probability to arrest smugglers and inflict them the penalty of smuggling (η) could not be determined analytically. This is one essential policy parameter: reinforcing the capacity of the border police to catch migrants in transit countries is one important target for the EU.

To provide some intuition on this important policy parameter, Table 6 focuses on the impact of η on the key policy variables. As revealed in the set "Exogenous N", increasing the probability of being arrested decreases the numbers of smugglers and incoming irregular migrants, raises the smuggling fee and the smuggler contact rate. It also drastically decreases the migrants welfare, as the fee goes up with η while the market tightness goes down.

Our results are in line with most of the literature: Friebel and Guriev (2006); Tamura (2010) and Djajić and Vinogradova (2014) all find that increasing border controls decreases debt-bonded migration; Tamura (2010) also shows that this would result in a lower number of smugglers (in the case of perfect information). Focusing on migration costs, Gathmann (2008) shows that tighter border controls result in geographic substitution, which leads to an increase in the smuggling fee.

Table 6: Simulation results for border policy

			Benchmark		
	(1)	(2)	(3)	(4)	(5)
Increases in η	$\eta = 0.10$	$\eta = 0.20$	$\eta = 0.30$	$\eta = 0.40$	$\eta = 0.50$
Tightness θ^*	0.95	0.704	0.459	0.225	0.02
Smuggling fee w^*	9.12	14.95	19.8	23.78	26.94
Smuggler contact rate $h(\theta^*)$	1.02	1.19	1.47	2.11	7.55
Migrants welfare V_s^{M*}	129.68	120.15	110.96	102.2	94.4
Exogenous ($N = 1000$)					
Incoming irregular migrants λM_t^*	1064	1049	1029	996	814
Smugglers S_s^*	1158	1076	930	684	167
Endogenous ($NR = 900, NE^*$)					
Economic migrants NE^*	117.6	108.7	100	91.7	84.4
Share of economic migrants ϕ_e^* (%)	12.0	11.0	10.0	09.0	08.6
Incoming irregular migrants λM_t^*	1083	1058	1029	988	802
Smugglers S_s^*	1179	1085	930	678	165

Note: Column (3) reports benchmark results, with parameters values summarized in Table 3. The exogenous N case refers to the case of forced migration only, while the endogenous N case refers to the case of voluntary and forced migration.

Voluntary migration The set "Endogenous N" in Table 5 presents simulations regarding parameters c, l, K, a, p and λ in the context of voluntary migration as introduced in section 5.

Taking into account the economic motive does not challenge the results obtained in the context of forced migration. Policies that directly target the smugglers' costs of doing business are relatively efficient in reducing the flows of irregular migrants and the number of active smugglers (except for policies increasing matching frictions which lead to an increase in the number of smugglers). As in the previous case, these measures also entail a reduction of migrants' welfare.

The effect of parameter η on the number of economic migrants could not be determined analytically (Proposition 4). Table 6 shows that a reduction of migrants' welfare induced by the tightening of the border policy leads to a fall in the incentives to migrate for economic reasons, as $\overline{z}$ and thus ϕ_e are negatively impacted.

6.2.3 Humanitarian policies and cooperation with origin countries

Humanitarian policies can be defined as the support that the EU provides to origin country governments to improve the living conditions of the residents, and eventually dissuade them from taking the decision to migrate to the EU. For example, in the Syrian case, the EU brought substantial support to the Turkish government to handle the refugee crisis and stabilize Syrian refugees in Turkey. For migrants from the Horn of Africa, such buffers do not exist, and the EU has developed actions to support job creation in these countries.

As before, we proceed in two steps: (i) we first focus on the case where N is kept constant (forced migration only); (ii) we then consider the case where N is responsive to the policy (forced and voluntary migration).

Table 1 has already revealed that the tightness θ^*, the fee w^* and the number of smugglers S_s^* are increasing in V, for any value of the continuation rate φ lower than 1. With an exogenous flow of new candidates to migration N, the number of irregular migrants reaching the destination country λM_t^* also goes up. As already highlighted in subsection 4.4, this result may seem paradoxical at first sight, but can be understood if we take into account the positive effect of V on the surplus from matching (eq. 31), linked to the push-back phenomenon. To our knowledge, this can be seen as an original result, as the existing literature on forced migration considers that migrants respond to forces beyond their control, and have "no choice but to leave" irrespective of their wealth or income at home. Our analysis does not contradict this argument, yet it brings into the picture a "second stage" economic choice, via the smuggling market, that has consequences on the number of persons who can leave the conflict area.

Table 7 presents a set of simulations that allow to better gauge this effect. We allowed for V to vary from a negative value $V = -25$ (residents' life is under threat) to an extremely generous local support, $V = 100$, through intermediate values $V = 5$ (our benchmark value) and $V = 25$.

The upper pane presents the equilibrium for $\varphi = 0.95$ (benchmark value). As one can see, in this case, the effects on the equilibrium variables are very small (because the "stay" option has a very small weight).[30] We can see that in the case of forced migration (constant N), the positive effect of V on the number of incoming irregular migrants is stronger the bigger the attrition rate $(1 - \varphi)$ is (a pushed-back migrant continues trying to migrate at rate φ).

This result seems to be reversed in the case of voluntary migrants (N endogenous). While migrants' welfare goes up with V, a rise in V also raises the incentives to stay in the country of origin and thus it reduces the incentives to migrate. Proposition 4 showed that the impact of V on the threshold cost of migration and thus on the number of economic migrants was ambiguous. In our simulations, the number of economic migrants decreases with V.

In the endogenous N context, the impact of a higher V on the total number of irregular migrants reaching borders is ambiguous. In our simulations, there are less economic migrants, yet more of the pushed back migrants will engage in irregular border crossing. The final impact of an increase in V depends on the value of the push-back rate. In our simulations, for $\varphi = 0.95$

[30] When $\varphi = 1$, V has no influence on the equilibrium variables, there is no offsetting effect.

and $\varphi = 0.75$, the total number of irregular migrants declines when the economic conditions in the country of origin improve, in line with intuitive reasoning (and the EU policies). However, as shown in the lower pane in Table 7, increasing V from 5 to 25 when the attrition rate is 0.5 would push up the numbers of smugglers and of irregular migrants. Actually, in this context, the best policy is either no support or full support to the locals, the worse being an "in-between" support. This special case should be seen as a caveat for policymakers, who should tailor their policies taking into account all their feedback effects.

Table 7: Simulation results for humanitarian policies

	(1)	(2)	(3)	(4)
$\varphi = 0.95$	$V = -25$	$V = 5$ (benchmark)	$V = 25$	$V = 100$
Tightness θ^*	0.44	0.459	0.47	0.51
Smuggling fee w^*	19.78	19.8	19.8	19.85
Smuggler contact rate $h(\theta^*)$	1.5	1.48	1.46	1.4
Migrants welfare V_s^M*	110.34	110.96	111.38	112.94
Exogenous ($N = 1000$)				
Incoming irregular migrants λM_t^*	1028	1029	1030	1032
Smugglers S_s^*	912	930	942	985
Endogenous ($NR = 900, NE^*$)				
Economic migrants NE^*	128	100	82	12
Share of economic migrants ϕ_e^* (%)	12.4	10.0	08.0	01.0
Incoming irregular migrants λM_t^*	1057	1029	1011	912
Smugglers S_s^*	937	930	924	898
$\varphi = 0.75$	$V = -25$	$V = 5$	$V = 25$	$V = 100$
Tightness θ^*	0.17	0.244	0.294	0.485
Smuggling fee w^*	19.38	19.51	19.59	19.82
Smuggler contact rate $h(\theta^*)$	2.42	2.02	1.84	1.43
Migrants welfare V_s^M*	100.12	102.9	104.78	111.94
Exogenous ($N = 1000$)				
Incoming irregular migrants λM_t^*	917	929	934	946
Smugglers S_s^*	504	612	676	879
Endogenous ($NR = 900, NE^*$)				
Economic migrants NE^*	118	92	75	11
Share of economic migrants ϕ_e^* (%)	12.0	09.3	07.7	01.0
Incoming irregular migrants λM_t^*	934	922	911	862
Smugglers S_s^*	513	607	659	801
$\varphi = 0.50$	$V = -25$	$V = 5$	$V = 25$	$V = 100$
Tightness θ^*	no sol.	0.03	0.11	0.457
Smuggling fee w^*	no sol.	19.02	19.27	19.79
Smuggler contact rate $h(\theta^*)$	no sol.	5.81	2.96	1.47
Migrants welfare V_s^M*	no sol.	94.86	98	110.89
Exogenous ($N = 1000$)				
Incoming irregular migrants λM_t^*	no sol.	762	822	857
Smugglers S_s^*	no sol.	175	370	773
Endogenous ($NR = 900, NE^*$)				
Economic migrants NE^*	no sol.	84	69	10
Share of economic migrants ϕ_e^* (%)	no sol.	08.6	07.0	01.0
Incoming irregular migrants λM_t^*	no sol.	751	796	780
Smugglers S_s^*	no sol.	172	358	703

Note: The parameters' values are the ones summarized in Table 3, except for parameter φ. Each block of the table provides the results obtained for different values of parameter φ. The exogenous N case applies to forced migration only, while the endogenous N case refers to the case of voluntary and forced migration.

Finally, it must be acknowledged that the analysis in this section revealed the effect of changes in parameters, one by one, on the equilibrium variables. In reality, none of these policies is implemented in isolation. To the contrary, the European Commission and its border control arm, Frontex, carry on multiple actions to deter irregular migration. Our aim here was to propose a careful analysis of the impact of a change in each policy parameter in order to provide a better understanding of the potential impact of such policies.

7 Conclusion

Irregular migration and migrant smuggling are two facets of the same phenomenon, and control of the former has important consequences on the latter.

Early studies have analyzed the market for smuggling services as a typical supply and demand problem. While static supply and demand models are quite useful in analyzing transparent markets with flexible prices and bring about many useful insights, migrant smuggling, as any illegal activity, is an opaque business, prone to significant trade frictions. Furthermore, it involves massive flows of candidates to migration, trying to meet those smugglers and ready to cross the borders several times until they eventually succeed in reaching the destination country. The flow of irregular migrants reaching the EU borders every period includes a substantial number of formerly pushed-back migrants. A matching model *à la* Pissarides (2000) provides a relevant framework to analyze such a flow market with substantial trade frictions.

The analysis has focused on the case of forced migration, including people who fled from war and conflict areas. However, an extension of the model allowed us to analyze, in a simplified decision framework, the case of voluntary migration, defined as a situation in which migrants choose to leave their home hoping for a better life in the rich world. These economic migrants follow the same routes as the forced migrants, and apply for asylum as well once they reached the destination area.

In our model, the legal immigration channel is extremely restricted, therefore most candidates to migration will engage in irregular migration, with the assistance of "professionals" of illegal border crossing, the smugglers.

Recent empirical evidence on irregular migration from Africa to Northern Europe suggests that smugglers are often organized as small businesses with a large degree of autonomy and independence. We therefore have assumed that smugglers are organized as small family businesses and can enter freely the smuggling sector until their profits fall down to zero. Candidates to migration meet smugglers with a matching probability that reflects the market frictions. We model the matching process by means of an original matching function inspired by the literature in labor economics, and solve the model for the steady state equilibrium, with endogenous numbers of smugglers and migrants impacting the smuggling fee.

The numbers of smugglers and irregular migrants reaching destination decrease with the costs associated to the smuggling activity. In particular, our simulations have shown that increasing the controls leading to a higher likelihood to catch the smuggler and the migrants during the journey or increasing the cost of being arrested for the smuggler should contribute to reducing the number of incoming irregular migrants. These findings are in line with the results of existing studies. Our analysis allows us to study the effect of these policies on the smuggling fee and the migrant welfare, and warns policymakers on the dramatic consequences of a raising burden on migrants that are already in an extremely fragile situation.

Similar to Auriol and Mesnard (2016), in our model simulations, a more generous legal visa policy would allow to reduce in a significant way the flow of irregular migrants and push smugglers out of the market; furthermore, in our model this favourable outcome is achieved without deteriorating migrants' welfare, nor increasing the total flows of migrants.

Because many of the pushed-back migrants return, a "moderate" asylum policy (not too tough, not too loose) might actually maximize the number of irregular migrants arriving every period, and lead to higher numbers of irregular migrants than a very lenient asylum policy.

Humanitarian policies providing incentives to residents not to leave bring about two offsetting effects on total irregular migration. On the one hand, a generous support would reduce economic migration. On the other hand, it entails a positive effect on the number of candidates to migration, mediated by a higher smuggling fee and a higher number of active smugglers. This effect might partially offset the effect of humanitarian support aiming to keep migrants at home; the net effect depends on the strength of the push-back phenomenon.

Our analysis was built on some simplifying assumptions; relaxing them might open interesting paths for future research. First, the drop-out rate for pushed-back migrants could be endogenized. This attrition rate could be a function increasing in the number of unsuccessful attempts, or decreasing in the smuggling fee. Second, in our model, the probability of authorities catching the migrants at the border has been kept exogenous for the sake of simplicity. A more realistic model might also make this probability endogenous, for instance by linking it to the size of the group of migrants guided by smugglers, as in Brausmann and Djajić (2022). Finally, the model used the "small firm" version of the matching model. Alternatively, it could be interesting to apply the "large firm" model to the smuggling business, where each migrant would be treated as the marginal migrant. In this case, the smuggler's outside option in case of disagreement would be the marginal value of his smuggling business, as he would provide his services to one less migrant.

Keeping in mind these ideas for further research, we hope to have convinced the reader that matching models provide a rigorous framework for analyzing the high-friction market for smuggling services, as well as useful insights for policymakers in finding the right balance between efficient deterrence of irregular border-crossing, and a concern for the welfare of asylum seekers.

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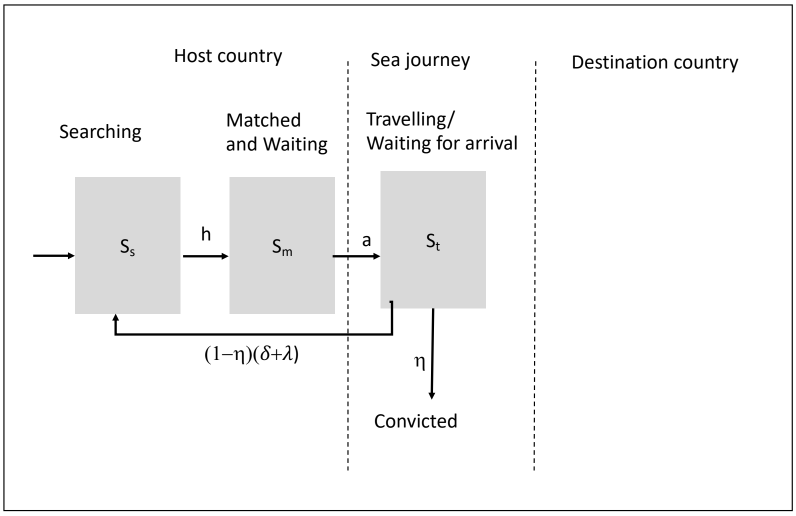
A Online Appendix

A.1 Flow diagram for the smugglers

Figure A.1: Flow diagram for the smugglers



Note: S_s, S_m and S_t denote the numbers of smugglers respectively searching for a candidate to migration, matched with a candidate and waiting for an opportunity to start the journey, and on the road or waiting for the smuggled migrant to arrive at destination.

A.2 Alternative fee determination: fixed fee and directed search

As an alternative to the previous case, let us assume instead that search is directed and smugglers advertise fees (as in competitive search models, see e.g. Moen, 1997). Accordingly, migrants choose where to queue for a smuggler by trading off a higher (resp. lower) fee against less (resp. more) time needed to reach a smuggler, and are indifferent in equilibrium. On their side, smugglers announce a fee maximising their value V_s^S taking into account the relationship between the fee and the arrival of migrants. Using equations (15) and (18), this can be written:

$$\begin{aligned} \max_{\theta,w} \left(rV_s^S\right) &= -c + h\left(\theta\right)\left(V_m^S - V_s^S\right) \\ \text{s.t.} \quad rV_s^M &= g\left(\theta\right)\left(V_m^M - V_s^M\right) + \sigma\left(Y - V_s^M\right) \end{aligned} \tag{A.1}$$

The Lagrangian of this problem writes:

$$L\left(\theta, w, \phi\right) = -c + h\left(\theta\right)\left(V_m^S - V_s^S\right) + \phi\left[rV_s^M - g\left(\theta\right)\left(V_m^M - V_s^M\right) - \sigma\left(Y - V_s^M\right)\right], \tag{A.2}$$

with ϕ the Lagrange multiplier.

The FOCs write in turn:

$$h'(\theta)\left(V_m^S - V_s^S\right) - \phi g'(\theta)\left(V_m^M - V_s^M\right) = 0 \tag{A.3}$$

$$h(\theta)\frac{\partial\left(V_m^S - V_s^S\right)}{\partial w} - \phi g(\theta)\frac{\partial\left(V_m^M - V_s^M\right)}{\partial w} = 0. \tag{A.4}$$

Dividing (A.3) by (A.4) and rearranging, we obtain:[31]

$$\frac{h'(\theta)}{h(\theta)}\frac{\partial\left(V_m^M - V_s^M\right)/\partial w}{V_m^M - V_s^M} = \frac{g'(\theta)}{g(\theta)}\frac{\partial\left(V_m^S - V_s^S\right)/\partial w}{V_m^S - V_s^S}. \tag{A.5}$$

Denoting $\alpha(\theta) = -\theta\frac{h'(\theta)}{h(\theta)} \in (0,1)$ the elasticity of the matching function, we obtain:

$$\alpha(\theta)\frac{\partial\left(V_m^M - V_s^M\right)/\partial w}{V_m^M - V_s^M} = -\left[1-\alpha(\theta)\right]\frac{\partial\left(V_m^S - V_s^S\right)/\partial w}{\left(V_m^S - V_s^S\right)}. \tag{A.6}$$

When the Hosios condition is met, this yields the same sharing rule as the one used in the text. One of the main differences between the two settings is that here, the ratio $1/\theta = M_s/S_s$ can be interpreted as the average number of migrants queuing for a smuggler, and therefore represents the queue length.

A.3 Partial equilibrium properties of the smuggling fee

Equation (26) can be written as:

$$\begin{aligned} w &= (1-\beta)\left(l + \frac{\eta K}{r+\delta+\eta+\lambda}\right) \\ &+\beta\left(\frac{\lambda\mu Y - \delta D + \left[\eta + \lambda(1-\mu)\right]\left[\varphi V_s^M + (1-\varphi)V\right]}{r+\delta+\eta+\lambda} - \frac{a+r}{a}V_s^M\right), \end{aligned} \tag{A.7}$$

with V_s^M given by eq. (28).

To determine the impact of the market tightness on the smuggling fee, notice that:

$$\frac{\partial w}{\partial \theta} = \frac{\partial w}{\partial V_s^M}\frac{\partial V_s^M}{\partial \theta} \leqslant 0, \tag{A.8}$$

thus w decreases with θ.

We denote $B = \left(\frac{r+\delta+\eta(1-\varphi)+\lambda[1-(1-\mu)\varphi]}{r+\delta+\eta+\lambda} + \frac{r}{a}\right) \geqslant 0$.

[31]Note that the same expression obtains by maximising $\left(rV_s^M\right)$ subject to $V_m^S = c/h(\theta)$.

The partial derivatives of the smuggling fee with respect to the parameters are:

$$\frac{\partial w}{\partial c} = -\left(1-\beta\right)\frac{\theta}{r+\sigma}B \leqslant 0 \tag{A.9}$$

$$\frac{\partial w}{\partial l} = 1-\beta \geqslant 0 \tag{A.10}$$

$$\frac{\partial w}{\partial \eta} = \left(1-\beta\right)\frac{\left(r+\delta+\lambda\right)K}{\left(r+\delta+\eta+\lambda\right)^2} - \beta\frac{\lambda\mu Y - \delta D - \left(r+\delta+\lambda\mu\right)\left[\left(1-\varphi\right)V + \varphi V_s^M\right]}{\left(r+\delta+\eta+\lambda\right)^2} \lesseqgtr 0 \tag{A.11}$$

$$\frac{\partial w}{\partial K} = \frac{\left(1-\beta\right)\eta}{r+\delta+\eta+\lambda} \geqslant 0 \tag{A.12}$$

$$\frac{\partial w}{\partial \delta} = -\frac{\left(1-\beta\right)\eta K + \beta\left\{\lambda\mu Y + \left(r+\eta+\lambda\right)D + \left[\eta+\lambda\left(1-\mu\right)\right]\left[\varphi V_s^M + \left(1-\varphi\right)\right]V\right\}}{\left(r+\delta+\eta+\lambda\right)^2} \leqslant 0 \tag{A.13}$$

$$\frac{\partial w}{\partial D} = \frac{-\beta\delta}{r+\delta+\eta+\lambda} \leqslant 0 \tag{A.14}$$

$$\begin{aligned}\frac{\partial w}{\partial \lambda} &= -\frac{\left(1-\beta\right)\eta K}{\left(r+\delta+\eta+\lambda\right)^2} \\ &\quad + \beta\left(\frac{\delta D + \mu\left(r+\delta+\eta\right)\left\{Y - \left[\varphi V_s^M + \left(1-\varphi\right)V\right]\right\} + \left(r+\delta\right)\left[\varphi V_s^M + \left(1-\varphi\right)V\right]}{\left(r+\delta+\eta+\lambda\right)^2}\right) \lesseqgtr 0\end{aligned} \tag{A.15}$$

$$\frac{\partial w}{\partial \mu} = \beta\lambda\left(\frac{Y - \left[\varphi V_s^M + \left(1-\varphi\right)V\right]}{r+\delta+\eta+\lambda}\right) \geqslant 0 \tag{A.16}$$

$$\frac{\partial w}{\partial Y} = \beta\left[\frac{\lambda\mu}{r+\delta+\eta+\lambda} - \frac{\sigma}{r+\sigma}B\right] \lesseqgtr 0 \tag{A.17}$$

$$\frac{\partial w}{\partial \varphi} = \beta\left(\frac{\left[\eta+\lambda\left(1-\mu\right)\right]\left(V_s^M - V\right)}{r+\delta+\eta+\lambda}\right) \geqslant 0 \tag{A.18}$$

$$\frac{\partial w}{\partial V} = \beta\left(\frac{\left[\eta+\lambda\left(1-\mu\right)\right]\left(1-\varphi\right)}{r+\delta+\eta+\lambda}\right) \geqslant 0 \tag{A.19}$$

$$\frac{\partial w}{\partial a} = \frac{r\beta V_s^M}{a^2} \geqslant 0 \tag{A.20}$$

$$\frac{\partial w}{\partial \sigma} = \left[\frac{\left(1-\beta\right)c\theta - \beta r Y}{\left(r+\sigma\right)^2}\right]B \lesseqgtr 0 \tag{A.21}$$

$$\frac{\partial w}{\partial p} = 0. \tag{A.22}$$

To determine the effect of the (smuggler's) bargaining power β on the fee w, let's re-write the surplus, using equations (16) to (20):

$$\Sigma = \frac{a}{a+r}\left[\left(V_t^M - \frac{a+r}{a}V_s^M\right) - \left(l + \frac{\eta K}{r+\delta+\eta+\lambda}\right)\right]. \tag{A.23}$$

It must be positive, otherwise the market is not viable, which implies that $V_t^M - \frac{a+r}{a} V_s^M \geqslant l + \frac{\eta K}{r+\eta+\lambda}$. Differentiating the fee equation (25) yields:

$$\frac{\partial w}{\partial \beta} = \left(V_t^M - \frac{a+r}{a} V_s^M\right) - \left(l + \frac{\eta K}{r+\delta+\eta+\lambda}\right) \geqslant 0. \tag{A.24}$$

A.4 Equilibrium properties of the smuggling market tightness

Let us now study the equilibrium properties of the tightness θ^*, which is the key endogenous variable of this model.

Equations (30) and (31) implicitly define θ^*:

$$\frac{c}{h(\theta^*)} = \beta \Sigma^*. \tag{A.25}$$

Differentiating with respect to any parameter X different from c, β, p, we obtain:

$$\frac{d\theta^*}{dX} = -\frac{h(\theta^*) d_X \Sigma^*}{h'(\theta^*)\Sigma^* + h(\theta^*) d_\theta \Sigma^*}. \tag{A.26}$$

Yet, equation (31) implies that the equilibrium surplus is decreasing with the market tightness:

$$d_\theta \Sigma^* = -\frac{a}{a+r} B \left(\frac{1-\beta}{\beta} \frac{c}{r+\sigma}\right) \leqslant 0. \tag{A.27}$$

Since $h'(\theta^*) \leqslant 0$ and $d_\theta \Sigma^* \leqslant 0$, the sign of $\frac{d\theta^*}{dX}$ is the sign of $d_X \Sigma^*$ for any $X \neq (c, \beta, p)$. These derivatives are the following:

$$d_l \Sigma^* = -\frac{a}{a+r} \leqslant 0 \tag{A.28}$$

$$d_\eta \Sigma^* = \frac{a}{a+r}\left(\frac{-(r+\delta+\lambda) K + \delta D - \lambda \mu Y + (r+\delta+\lambda\mu)\left[\varphi V_s^M + (1-\varphi) V\right]}{(r+\delta+\eta+\lambda)^2}\right) \lesseqgtr 0 \tag{A.29}$$

$$d_K \Sigma^* = -\frac{a}{a+r} \frac{\eta}{r+\delta+\eta+\lambda} \leqslant 0 \tag{A.30}$$

$$d_\delta \Sigma^* = -\frac{a}{a+r} \frac{-\eta K + \lambda\mu Y + (r+\eta+\lambda) D + [\eta + \lambda(1-\mu)]\left[\varphi V_s^M + (1-\varphi) V\right]}{(r+\delta+\eta+\lambda)^2} \lesseqgtr 0 \tag{A.31}$$

$$d_D \Sigma^* = -\frac{a}{a+r} \frac{\delta}{r+\delta+\eta+\lambda} \leqslant 0 \tag{A.32}$$

$$d_\lambda \Sigma^* = \frac{a}{a+r} \frac{\eta K + (r+\delta+\eta)\mu\left\{Y - \left[\varphi V_s^M + (1-\varphi) V\right]\right\} + \delta D + (r+\delta)\left[\varphi V_s^M + (1-\varphi) V\right]}{(r+\delta+\eta+\lambda)^2} \geqslant 0 \tag{A.33}$$

$$d_\mu \Sigma^* = \frac{a}{a+r} \frac{\lambda}{r+\delta+\eta+\lambda}\left\{Y - \left[(1-\varphi) V + \varphi V_s^M\right]\right\} \geqslant 0 \tag{A.34}$$

$$d_Y \Sigma^* = \frac{a}{a+r}\left[\frac{\lambda\mu}{r+\delta+\eta+\lambda} - \frac{\sigma}{r+\sigma} B\right] \lesseqgtr 0 \tag{A.35}$$

$$d_{\varphi}\Sigma^* = \frac{a}{a+r}\frac{\eta+\lambda(1-\mu)}{r+\delta+\eta+\lambda}\left[V_s^M - V\right] \geqslant 0 \tag{A.36}$$

$$d_V\Sigma^* = \frac{a}{a+r}\frac{[\eta+\lambda(1-\mu)](1-\varphi)}{r+\delta+\eta+\lambda} \geqslant 0 \tag{A.37}$$

$$d_a\Sigma^* = \frac{r}{a(a+r)}\left(\Sigma^* + V_s^M\right) \geqslant 0 \tag{A.38}$$

$$d_{\sigma}\Sigma^* = -\frac{a}{a+r}B\left(\frac{rY}{(r+\sigma)^2} - \frac{1-\beta}{\beta}\frac{c\theta^*}{(r+\sigma)^2}\right) \lesseqgtr 0. \tag{A.39}$$

For parameters c and β, we have:

$$\frac{d\theta^*}{dc} = -\frac{h(\theta^*)\,d_c\Sigma^* - \frac{1}{\beta}}{h'(\theta^*)\,\Sigma^* + h(\theta^*)\,d_{\theta}\Sigma^*} \tag{A.40}$$

$$\frac{d\theta^*}{d\beta} = -\frac{\frac{c}{\beta^2} + h(\theta^*)\,d_{\beta}\Sigma^*}{h'(\theta^*)\,\Sigma^* + h(\theta^*)\,d_{\theta}\Sigma^*}. \tag{A.41}$$

Thus $\frac{d\theta^*}{dc}$ and $\frac{d\theta^*}{d\beta}$ are respectively of the same sign as $\left(h(\theta^*)\,d_c\Sigma^* - \frac{1}{\beta}\right)$ and $\left(\frac{c}{\beta^2} + h(\theta^*)\,d_{\beta}\Sigma^*\right)$. The partial derivatives of interest are:

$$d_c\Sigma^* = -\frac{a}{a+r}B\left(\frac{1-\beta}{\beta}\frac{\theta^*}{r+\sigma}\right) \leqslant 0 \tag{A.42}$$

$$d_{\beta}\Sigma^* = \frac{a}{a+r}B\left(\frac{1}{\beta^2}\frac{c\theta^*}{r+\sigma}\right) \geqslant 0. \tag{A.43}$$

This implies that:

$$h(\theta^*)\,d_c\Sigma^* - \frac{1}{\beta} \leqslant 0 \tag{A.44}$$

$$\frac{c}{\beta^2} + h(\theta^*)\,d_{\beta}\Sigma^* \geqslant 0. \tag{A.45}$$

Finally, for parameter p, we have:

$$\frac{d\theta^*}{dp} = -\frac{\Sigma^* d_p h(\theta^*)}{d_{\theta}h(\theta^*)\,\Sigma^* + h(\theta^*)\,d_{\theta}\Sigma^*}. \tag{A.46}$$

Thus $\frac{d\theta^*}{dp}$ is of the same sign as $d_p h(\theta^*)$, which is positive.

A.5 Equilibrium properties of the smuggling fee

Let us now study the equilibrium properties of the equilibrium smuggling fee w^*, which is the other key endogenous variable of this model, given by equation (29).

For any parameter X, we have:

$$\frac{dw^*}{dX} = \frac{\partial w^*}{\partial X} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-}\frac{d\theta^*}{dX}. \tag{A.47}$$

Then, for parameters η, δ, λ, Y and σ, we have:

$$\frac{dw^*}{d\eta} = \underbrace{\frac{\partial w^*}{\partial \eta}}_{+/-} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \underbrace{\frac{d\theta^*}{d\eta}}_{+/-} \lesseqgtr 0 \tag{A.48}$$

$$\frac{dw^*}{d\delta} = \underbrace{\frac{\partial w^*}{\partial \delta}}_{-} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \underbrace{\frac{d\theta^*}{d\delta}}_{+/-} \lesseqgtr 0 \tag{A.49}$$

$$\frac{dw^*}{d\lambda} = \underbrace{\frac{\partial w^*}{\partial \lambda}}_{+/-} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \underbrace{\frac{d\theta^*}{d\lambda}}_{+} \lesseqgtr 0 \tag{A.50}$$

$$\frac{dw^*}{dY} = \underbrace{\frac{\partial w^*}{\partial Y}}_{+/-} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \underbrace{\frac{d\theta^*}{dY}}_{+/-} \lesseqgtr 0 \tag{A.51}$$

$$\frac{dw^*}{d\sigma} = \underbrace{\frac{\partial w^*}{\partial \sigma}}_{+/-} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \underbrace{\frac{d\theta^*}{d\sigma}}_{+/-} \lesseqgtr 0. \tag{A.52}$$

Similarly, for parameters l, K and p, we simply obtain:

$$\frac{dw^*}{dl} = \underbrace{\frac{\partial w^*}{\partial l}}_{+} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \underbrace{\frac{d\theta^*}{dl}}_{-} \geqslant 0 \tag{A.53}$$

$$\frac{dw^*}{dK} = \underbrace{\frac{\partial w^*}{\partial K}}_{+} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \underbrace{\frac{d\theta^*}{dK}}_{-} \geqslant 0 \tag{A.54}$$

$$\frac{dw^*}{dp} = \underbrace{\frac{\partial w^*}{\partial p}}_{0} + \underbrace{\frac{\partial w^*}{\partial \theta^*}}_{-} \underbrace{\frac{d\theta^*}{dp}}_{+} < 0. \tag{A.55}$$

For parameter $X = c, D, \mu, \varphi, V, a, \beta$, we have:

$$sign \frac{\partial w^*}{\partial X} = -sign \frac{\partial w^*}{\partial \theta^*} \frac{d\theta^*}{dX}, \tag{A.56}$$

so, to be able to conclude, we must replace $\frac{\partial w^*}{\partial X}$, $\frac{\partial w^*}{\partial \theta^*}$ and $\frac{d\theta^*}{dX}$ with their expressions.

For parameter $X = D, \mu, \varphi, V, a$, $\frac{d\theta^*}{dX}$ is derived from equation (30):

$$\frac{d\theta^*}{dX} = \frac{\beta d_X \Sigma^*}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} - \beta d_\theta \Sigma^*} = \frac{\beta d_X \Sigma^*}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B\,(1-\beta)\,\frac{a}{a+r}\frac{c}{r+\sigma}}. \tag{A.57}$$

We then obtain:

$$\frac{dw^*}{dD} = \frac{-\beta\delta}{r+\delta+\eta+\lambda}\left\{\frac{-\frac{ch'(\theta^*)}{h^2(\theta^*)}}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta)\frac{a}{a+r}\frac{c}{r+\sigma}}\right\} \leqslant 0 \tag{A.58}$$

$$\frac{dw^*}{d\mu} = \beta\lambda\left(\frac{Y - \left[\varphi V_s^M + (1-\varphi)V\right]}{r+\delta+\eta+\lambda}\right)\left\{\frac{-\frac{ch'(\theta^*)}{h^2(\theta^*)}}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + (1-\beta)B\frac{a}{a+r}\frac{c}{r+\sigma}}\right\} \geqslant 0 \tag{A.59}$$

$$\frac{dw^*}{d\varphi} = \beta\frac{\left[\eta+\lambda(1-\mu)\right]\left(V_s^M - V\right)}{r+\delta+\eta+\lambda}\left\{\frac{-\frac{ch'(\theta^*)}{h^2(\theta^*)}}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta)\frac{a}{a+r}\frac{c}{r+\sigma}}\right\} \geqslant 0 \tag{A.60}$$

$$\frac{dw^*}{dV} = \beta\left(\frac{\left[\eta+\lambda(1-\mu)\right](1-\varphi)}{r+\delta+\eta+\lambda}\right)\left\{\frac{-\frac{ch'(\theta^*)}{h^2(\theta^*)}}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta)\frac{a}{a+r}\frac{c}{r+\sigma}}\right\} \geqslant 0 \tag{A.61}$$

$$\frac{dw^*}{da} = \underbrace{\frac{r\beta V_s^M}{a^2}\left(\frac{-\frac{ch'(\theta^*)}{h^2(\theta^*)}}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta)\frac{a}{a+r}\frac{c}{r+\sigma}}\right)}_{+} \underbrace{-\frac{B(1-\beta)\frac{c}{r+\sigma}\beta\frac{r}{a(a+r)}\Sigma^*}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta)\frac{a}{a+r}\frac{c}{r+\sigma}}}_{-} \gtreqless 0. \tag{A.62}$$

For parameter c, we have:

$$\frac{dw^*}{dc} = -B(1-\beta)\frac{\theta^*}{r+\sigma}\left(1 + \frac{c}{\theta^*}\frac{d\theta^*}{dc}\right) \lesseqgtr 0. \tag{A.63}$$

Thus if $\frac{c}{\theta^*}\frac{d\theta^*}{dc} > -1$, then $\frac{dw^*}{dc} < 0$; conversely, if $\frac{c}{\theta^*}\frac{d\theta^*}{dc} < -1$, then $\frac{dw^*}{dc} > 0$.

For parameter β, we have:

$$\frac{d\theta^*}{d\beta} = \frac{\Sigma^* + \beta d_\beta \Sigma^*}{d_\theta\left(\beta\Sigma^* - \frac{ch(\theta^*)}{h(\theta^*)}\right)} = \frac{\Sigma^* + \frac{1}{\beta}\frac{aB}{a+r}\frac{c\theta^*}{r+\sigma}}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta)\frac{a}{a+r}\frac{c}{r+\sigma}}. \tag{A.64}$$

Thus:

$$\frac{dw^*}{d\beta} = \frac{B}{\beta}\frac{\sigma Y}{r+\sigma} + \left(\frac{a+r}{a}\Sigma^* + \frac{B}{\beta}\frac{c\theta^*}{r+\sigma}\right)\left[\frac{-\frac{ch'(\theta^*)}{h^2(\theta^*)}}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta)\frac{a}{a+r}\frac{c}{r+\sigma}}\right] \geqslant 0. \tag{A.65}$$

A.6 Properties of the smuggler contact rate

For any parameter $X \neq p$, the smuggler contact rate varies in the opposite direction as the tightness θ^* since we have:

$$\frac{dh(\theta^*)}{dX} = \underbrace{h'(\theta^*)}_{-}\frac{d\theta^*}{dX}. \tag{A.66}$$

Its variations with respect to parameter p are ambiguous:

$$\frac{dh(\theta^*)}{dp} = \underbrace{\frac{h(\theta^*)}{p}}_{+} + \underbrace{h'(\theta^*)}_{-}\underbrace{\frac{d\theta^*}{dp}}_{+} \lesseqgtr 0. \tag{A.67}$$

Introducing the elasticity of the matching function, $\alpha(\theta) = -\theta \frac{h'(\theta)}{h(\theta)}$, we can write:

$$\frac{dh(\theta^*)}{dp} = \frac{\theta^*}{p} h'(\theta^*) \left(\frac{p}{\theta^*} \frac{d\theta^*}{dp} - \frac{1}{\alpha(\theta^*)} \right). \tag{A.68}$$

Thus $h(\theta^*)$ increases with p if and only if $\frac{p}{\theta^*} \frac{d\theta^*}{dp} \geqslant \frac{1}{\alpha(\theta^*)}$.

A.7 Properties of the migrants welfare

The migrants welfare is given by equation (28):

$$V_s^{M*} = \frac{\sigma Y}{r+\sigma} + \frac{1-\beta}{\beta} \frac{c\theta^*}{r+\sigma}. \tag{A.69}$$

For any parameter $X \neq Y, \sigma, c, \beta$, we have:

$$\frac{dV_s^M}{dX} = \frac{1-\beta}{\beta} \frac{c}{r+\sigma} \frac{d\theta^*}{dX}. \tag{A.70}$$

Thus V_s^M varies like θ^* for these parameters.

For parameters Y, σ, c, β, we have:

$$\frac{dV_s^M}{dY} = \frac{\sigma}{r+\sigma} + \frac{1-\beta}{\beta} \frac{c}{r+\sigma} \underbrace{\frac{d\theta^*}{dY}}_{+/-} \lesseqgtr 0 \tag{A.71}$$

$$\frac{\partial V_s^M}{\partial \sigma} = \frac{rY}{(r+\sigma)^2} + \frac{1-\beta}{\beta} \frac{c}{r+\sigma} \left(\underbrace{\frac{d\theta^*}{d\sigma}}_{+/-} - \frac{\theta^*}{r+\sigma} \right) \lesseqgtr 0 \tag{A.72}$$

$$\frac{dV_s^M}{dc} = \frac{1-\beta}{\beta} \frac{\theta^*}{r+\sigma} \left(1 + \frac{c}{\theta^*} \underbrace{\frac{\partial \theta^*}{\partial c}}_{-} \right) \tag{A.73}$$

$$= -\frac{1-\beta}{\beta} \frac{c}{r+\sigma} \frac{1}{h(\theta^*)} \left(\frac{1-\alpha(\theta^*)}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta) \frac{a}{a+r} \frac{c}{r+\sigma}} \right) < 0 \tag{A.74}$$

$$\frac{dV_s^M}{d\beta} = \frac{c}{r+\sigma} \left(\frac{1-\beta}{\beta} \underbrace{\frac{\partial \theta^*}{\partial \beta}}_{+} - \frac{\theta^*}{\beta^2} \right) \tag{A.75}$$

$$= \frac{c}{r+\sigma} \frac{\Sigma^*}{\beta} \left(\frac{(1-\beta) - \alpha(\theta^*)}{-\frac{ch'(\theta^*)}{h^2(\theta^*)} + B(1-\beta) \frac{a}{a+r} \frac{c}{r+\sigma}} \right) \lesseqgtr 0. \tag{A.76}$$

Therefore $sign(\frac{dV_s^M}{d\beta}) = sign(1-\beta-\alpha(\theta^*))$

A.8 Properties of the number of incoming migrants

The number of incoming migrants λM_t^* is given by equation (11):

$$\lambda M_t^* = \frac{\lambda N}{\frac{\sigma}{g(\theta^*)}\left(\delta+\eta+\lambda\right)+\delta+\eta\left(1-\varphi\right)+\lambda\left[1-\varphi\left(1-\mu\right)\right]}. \tag{A.77}$$

It is increasing with the tightness θ^*:

$$\frac{\partial \lambda M_t^*}{\partial \theta^*} = \left(\lambda M_t^*\right)^2 \frac{\sigma\left(\delta+\eta+\lambda\right)}{\lambda N}\frac{g'\left(\theta^*\right)}{g^2\left(\theta^*\right)} \geqslant 0. \tag{A.78}$$

For parameter $X = c, l, K, D, Y, V, a, \beta$, we have:

$$\frac{d\lambda M_t^*}{dX} = \underbrace{\frac{\partial \lambda M_t^*}{\partial \theta^*}}_{+}\frac{d\theta^*}{dX}. \tag{A.79}$$

Thus λM_t^* varies like θ^* for these parameters.

For parameter $X = \eta, \delta, \mu, \varphi, \sigma, p$, we have:

$$\frac{d\lambda M_t^*}{dX} = \frac{\partial \lambda M_t^*}{\partial X} + \frac{\partial \lambda M_t^*}{\partial \theta^*}\frac{d\theta^*}{dX} \tag{A.80}$$

$$\frac{d\lambda M_t^*}{d\eta} = -\frac{\left(\lambda M_t^*\right)^2}{\lambda N}\left[1-\varphi+\frac{\sigma}{g\left(\theta^*\right)}\left(1-\left(\delta+\eta+\lambda\right)\frac{g'\left(\theta^*\right)}{g\left(\theta^*\right)}\underbrace{\frac{d\theta^*}{d\eta}}_{+/-}\right)\right] \lesseqgtr 0 \tag{A.81}$$

$$\frac{d\lambda M_t^*}{d\delta} = -\frac{\left(\lambda M_t^*\right)^2}{\lambda N}\left[1+\frac{\sigma}{g\left(\theta^*\right)}\left(1-\left(\delta+\eta+\lambda\right)\frac{g'\left(\theta^*\right)}{g\left(\theta^*\right)}\underbrace{\frac{d\theta^*}{d\delta}}_{+/-}\right)\right] \lesseqgtr 0 \tag{A.82}$$

$$\frac{d\lambda M_t^*}{d\mu} = -\frac{\left(\lambda M_t^*\right)^2}{\lambda N}\left[\lambda\varphi-\sigma\left(\delta+\eta+\lambda\right)\frac{g'\left(\theta^*\right)}{g^2\left(\theta^*\right)}\underbrace{\frac{d\theta^*}{d\mu}}_{+}\right] \lesseqgtr 0 \tag{A.83}$$

$$\frac{d\lambda M_t^*}{d\varphi} = \frac{\left(\lambda M_t^*\right)^2}{\lambda N}\left[\eta+\lambda\left(1-\mu\right)+\sigma\left(\delta+\eta+\lambda\right)\frac{g'\left(\theta^*\right)}{g^2\left(\theta^*\right)}\underbrace{\frac{d\theta^*}{d\varphi}}_{+}\right] \geqslant 0 \tag{A.84}$$

$$\frac{d\lambda M_t^*}{d\sigma} = -\frac{\left(\lambda M_t^*\right)^2}{\lambda N}\frac{\delta+\eta+\lambda}{g\left(\theta^*\right)}\left[1-\frac{\sigma g'\left(\theta^*\right)}{g\left(\theta^*\right)}\underbrace{\frac{d\theta^*}{d\sigma}}_{+/-}\right] \lesseqgtr 0 \tag{A.85}$$

$$\frac{d\lambda M_t^*}{dp} = \frac{\left(\lambda M_t^*\right)^2}{\lambda N}\frac{\sigma\left(\delta+\eta+\lambda\right)}{g^2\left(\theta^*\right)}\left[\underbrace{d_p g\left(\theta^*\right)}_{+}+g'\left(\theta^*\right)\underbrace{\frac{d\theta^*}{dp}}_{+}\right] \geqslant 0. \tag{A.86}$$

For parameter λ, we have:

$$\frac{d\lambda M_t^*}{d\lambda} = M_t^* \left[1 - \frac{(M_t^*)^2}{N}\right] \left[1 - \varphi(1-\mu) + \frac{\sigma}{g(\theta^*)} \left(1 - (\delta+\eta+\lambda) \frac{g'(\theta^*)}{g(\theta^*)} \underbrace{\frac{\partial \theta^*}{\partial \lambda}}_{+}\right)\right] \lesseqgtr 0. \tag{A.87}$$

A.9 Properties of the number of searching smugglers

The number of searching smugglers S_s^* is given by equation (13):

$$S_s^* = \frac{\delta+\eta+\lambda}{h(\theta^*)} M_t^*. \tag{A.88}$$

It is increasing with the tightness θ^*:

$$\frac{\partial S_s^*}{\partial \theta^*} = \frac{\delta+\eta+\lambda}{h^2(\theta^*)} \left[h(\theta^*) \underbrace{\frac{\partial M_t^*}{\partial \theta^*}}_{+} - M_t^* \underbrace{h'(\theta^*)}_{-}\right] \geqslant 0. \tag{A.89}$$

For any parameter $X \neq \eta, \delta, \lambda, p$, we have:

$$\frac{dS_s^*}{dX} = \frac{\delta+\eta+\lambda}{h(\theta^*)} \frac{dM_t^*}{dX}. \tag{A.90}$$

Thus S_s^* varies like M_t^* for these parameters.
Note that:

$$\frac{dM_t^*}{d\lambda} = \frac{1}{\lambda} \left[\underbrace{\frac{d\lambda M_t^*}{d\lambda}}_{+/-} - M_t^*\right] \lesseqgtr 0. \tag{A.91}$$

For parameter $X = \eta, \delta, \lambda$, we have:

$$\frac{dS_s^*}{dX} = \frac{M_t^*}{h(\theta^*)} + \frac{\delta+\eta+\lambda}{h^2(\theta^*)} \left(h(\theta^*) \underbrace{\frac{dM_t^*}{dX}}_{+/-} - M_t^* \frac{dh(\theta^*)}{dX}\right) \lesseqgtr 0. \tag{A.92}$$

For parameter p, we have:

$$\frac{dS_s^*}{dp} = \frac{\delta+\eta+\lambda}{h^2(\theta^*)} \left(h(\theta^*) \underbrace{\frac{dM_t^*}{dp}}_{+} - M_t^* \underbrace{\frac{dh(\theta^*)}{dp}}_{+/-}\right) \lesseqgtr 0. \tag{A.93}$$

A.10 Properties of the threshold cost of migration

From equation (34), we know that:

$$\overline{z} = V_s^M - V. \tag{A.94}$$

For any parameter $X \neq V$, we have:

$$\frac{d\overline{z}}{dX} = \frac{dV_s^M}{dX}. \tag{A.95}$$

Thus $\overline{z}$ varies like V_s^M for these parameters.

For parameter V, we have:

$$\frac{d\overline{z}}{dV} = \frac{dV_s^M}{dV} - 1 \lesseqgtr 0. \tag{A.96}$$